SCIENCE AND THE MILLER

JOHN·STEWART·REMINGTON

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GENERAL VIEW, AYNSOME LABORATORIES.

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BY

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PREFACE

THIS little Book is the result of an effort to present some of the main facts educational and scientific of importance to the Milling Trade at the present time, believing as I do, that the education of our future millers must proceed side by side with the advancement of Science and Technical progress. I have, therefore, touched upon certain subjects which, from close observation as well as from a scientific and practical point of view, have in my opinion a direct bearing on the business success of a modern Flour Mill.

It is with an earnest desire—irrespective altogether from business considerations—to help the Milling Trade, that I have ventured to produce this book, hoping apart from its many shortcomings that within its pages something of interest may be found, both for the older members of the Trade, who no longer can afford the necessary time for scientific study, as well as for the younger generation of Millers who are now setting out on their life work, and represent the men who will with tomorrow's dawn be expected to uphold the great traditions of British Milling.

AYNSOME HOUSE,
November, 1913.

Dedicated

to

MY WIFE

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THE CHEMIST AND THE COMMUNITY

THE CHEMIST AND THE COMMUNITY

I LIKE a book to have a motto of its own, and so for a motto for this one I have looked back fourteen hundred years and taken a saying from the mouth of a shepherd and camel driver, called Prophet by half the human race. That camel driver Mahomet was a very practical minded man and said a number of clever things, that are as true for the business men of the twentieth century as for his first sallow skinned followers.

Among his sayings was this: "Trust in Heaven, but tie up your camel," and this saying I have taken as the motto for my book, which has been suggested by the fact that so many of our English manufacturers seem ready to trust in the heavens of Protection or Free Trade, and are quite content to leave their camels straying and uncared for, and so this is what I want this book to be, no more than a reminder that it is advisable to look to the camels themselves before asking the heavens to see to them.

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The camel of the British manufacturer is his business. The heavens, which I wish him to forget for a little while, are the artificial aids to tariffs, or the absence of them.

In the place of these artificial aids I would substitute a desire on the part of every manufacturer for a closer understanding of what is known as the "Scientific Method" and to wish to learn the important part that the chemist has played, and is destined to play in the near future, in the business evolution of industry and commerce.

Chemistry enters so intimately, even though unobtrusively, into every phase of modern life that it is perhaps impossible in one short chapter to present in any adequate degree the real dependence of the community upon the work of chemists, past and present.

If we were to take away what chemists have contributed in the past, the whole structure of modern society would break down at once.

Commercial transactions of every kind in the civilised world are based upon the certificate of the chemist, from the food we

eat down to the purity of the gold which forms our ultimate measure of value.

Faith may remove mountains, but modern society relies on cordite, for without explosives our great engineering works must cease, and modern warfare would become impossible.

When we consider the rise and fall in prices, with variations of the world's gold supply, many little think that market prices everywhere are influenced by the increase in this supply, which in a great measure can be ascribed to the cyanide and chlorination methods of gold refining, the work of the chemist.

Industrial revolutions are seldom chronicled and still more rarely celebrated, though their influence upon the welfare of mankind may be as profound as those of other revolutions, the records of which are traced in blood.

The chemist, by substituting the scientific method for the "rule of thumb" has profoundly influenced all commercial undertakings.

To take only one or two instances at random, it may be mentioned that the art

of the dyer is now entirely in the hands of the chemist. It is only a short time ago that the commercial and scientific world celebrated the fiftieth anniversary of the discovery of Mauve the first of the Coal Tar colours, and were happy in the knowledge that its discoverer was still among them to receive their congratulations and rejoice with them at the splendid outgrowth of his work. As a result of this work, profound economic changes have been brought about in England, Germany, France and the United States. Our fastest dyes are now produced synthetically, and the range of the dyer's art has been widely extended.

In the manufacture of paints and pigments new processes have been developed in the making of White Lead, Zinc Oxide, Lithopone and a host of mineral pigments not to speak of the various lakes and fine colours, used by coach and motor car builders, printing ink manufacturers and others.

In considering the activity of the chemist in the manufacture of Paper, Celluloid, Collodion, Photographic Films,

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Smokeless Powder, Artificial Silk, Artificial Leather, etc. and in all those industries that are intimately connected with the most widely distributed of all the carbohydrates, known as Cellulose, a wide and ever increasing vista, endless research, scientific skill, and commercial enterprise opens up before us. Take one example only, that of Artificial Silk. Its history is an interesting one, for it is a step in that line of artificiality which constitutes the progress of man, which has completely transformed human industries and to which the principal features, which distinguish civilisation from savagery are traceable, by the substitution of an artificial for a natural product. After the discovery of Nitrocellulose in 1846 repeated attempts were made to produce artificial silk from this material, but without success, until Count Chardounet devised, in the year 1885, his process of drawing fine threads of Collodion through water, and thus produced by this means, fibres, sufficiently strong to be woven. On account, however, of the inflammable nature of Nitrocellulose the danger of fire rendered the resulting fabric unsafe to wear. To remedy this drawback

a process of "denitration" was adopted by which the material was relieved of this dangerous tendency. In addition to the advantage over celluloid material which had not been subjected to the denitration, the new product possessed the property of being easily dyed. In appearance the artificial product resembled natural silk, except that it burnt rather more easily. Another substitute for silk, which has been much employed, has developed from the old process of "Mercerisation." On treating cotton with an alkaline solution, a shiny and resistant surface is imparted to the fibre and the product is sold under the name of "Spun Silk." If the mercerisation process is carried further the cellulose swells up to a gelatinous mass which is insoluble in water. In 1892 Cross and Bevan found that if to this gelatinous alkaline mass, a small proportion of carbon bisulphide was added, the cellulose entered completely into solution, forming a viscous liquid. This new substance they termed Viscose. For some time this invention failed to find immediate application, but later it was found possible to produce from viscose, fibres from which an artificial silk

could be cheaply produced, cheaper in fact than by any other process. In other directions the work of the chemist has been no less active. The cotton spinner, tanner, brewer, iron founder, sanitary engineer, soap maker and cattle-food manufacturer have all benefited and improved their various trades, by calling in the aid of science, though at no distinct date they were entirely dominated by the " rule of thumb " system. So if every industry known to us has benefited by adopting the " Scientific Method," surely a great industry like Milling, should do so also. Yet it would appear to be the last of our industries to call in the aid of the chemist. Up to the present only a few mills have employed the services of a scientist in their business. It is only thirty years ago, that the old system of stone milling was supplanted by the roller system, and with the introduction of this type of machinery, all the advancement made in Milling has been from the engineering standpoint. The improvement of milling machinery has progressed by leaps and bounds, so that to-day it may be said to be well nigh perfect. It would therefore seem natural, that any system which has depended

entirely on physical and mechanical means, such as separation by air currents, separation by sieves, and the gravity of particles, should in time give place to the chemistry of the products with which it has to deal. We are in fact on the verge of a new era, as regards milling, when we enter the domain of chemical science.

Now that more attention is being paid to systems of conditioning, and processes for the improvement of wheat and flour are before the Trade, it behoves millers to look to the chemical side of their business more than they have done in the past, for undoubtedly, in the future, chemistry is destined to play as important a part in the manufacture of flour, as mechanical science has done in the past. Let the millers of the United Kingdom therefore, not neglect the "writing on the wall" for there can be no doubt that those who disregard the advancements made by Science, will, on being weighed in the balance of Commercial Progress, be found wanting. At the commencement of this chapter, it was suggested that millers should "trust in Heaven but tie up their camels" but in doing so, let them also make sure when looking into

the future, that the rope by which the camel is tied is one in which the strands of Science are surely interwoven, and further remember that it is by Science and by looking carefully after the things pertaining to Natural Knowledge, that the development and progress of the Milling Industry of Great Britain and Ireland is to be assured.

THE YOUNG MASTER MILLER

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AT the present time many magazines and trade journals have devoted much space to the subject of the different causes affecting various manufacturing trades in this Country, and to the importance of a proper training for those who wish to qualify themselves for the position of Heads of business and future Principals, having a better grasp of Science and its ways, than their forefathers had.

From whatever point of view the subject is approached however, it is certain that a technical training is rapidly gaining favour among our leaders of commerce, and as shown in the first chapter, the directors of such industries as the manufacture of Textiles, Leather, Soap and Colours, have for sometime recognised the importance and necessity of Science.

Millers, as previously stated, have made very little use of scientific methods and scientific control as applied to the modern system of flour manufacture.

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The milling trade of England is in rather a state of transition, the large port mills making it increasingly difficult for the inland and country miller to make even a moderate profit, so that in some cases it would almost appear better for some firms to merchant grain, than manufacture flour. It is therefore most essential that all those engaged in the milling of wheat should take hold of every advantage presented to them by the advancement of science, in order to meet increasing competition.

My object is to consider science, and its possibilities in relation to the work of the miller, as well as the attitude of the miller in relation to science.

At the outset, there is a curious fact. The science of Milling Engineering has advanced in a marvellous and wholly admirable manner, during the last thirty years, and many mills are models of economical management and enterprise, but the equally important science of milling materials, the Chemistry of milling so to speak is in a neglected, though not exactly in a backward condition

The science itself is all right, but millers, except in a very few cases have been slow to

take advantage of it. Those however, who have allowed a progressive spirit to stimulate their business, have found the adoption of scientific tests a very necessary adjunct to the successful working of a modern flour mill.

I will now turn to the question of the training a young miller should undergo, and here we come, as regards the smaller mills, to the very important question, as to who is best fitted to undertake the duties of testing and scientific control.

Millers being, on the whole, a very conservative race of men, who resist most strenuously the introduction of any outsider into their business, and moreover are very jealous of their secrets and pet methods of working, are not inclined to trust a stranger. It would therefore certainly appear, that as it is essential that the master miller of the future should have an intimate knowledge of science, the best person to undertake the testing duties in mills, from three to fifteen sack capacity, would be the son of the Principal, or some young relative working in the mill, and who in due course would attain an important position in the business.

The reason for suggesting this is as follows:—In most cases it may be assumed that the young master miller will have received a good general education, such as is provided on the modern side of our large Public schools, or Grammar schools, special attention having been paid to Mathematics, Algebra, Plane Trigonometry, Freehand drawing, English Literature, History, Geography, Composition, Latin, French or German, and Shorthand. Having gained a fair knowledge of these subjects, the young master miller, after leaving school, either enters as an apprentice in another mill, or goes to one of the works of some well known Firm of Milling Engineers, in order to obtain a thorough insight into the practical side of his milling business. Should he enter a mill, he will in exchange for his premium, be allowed to sweep the floors, help to load the wagons, and clean out the washing tackle, and generally for some time, do a lot of work with his hands, and little with his head; afterwards of course, developing his real milling skill if he has any.

Now this training is very necessary and admirable. Let any young miller follow the course I have outlined, and he is certain to get

a thorough practical knowledge of the running of a mill, the value of which can hardly be over estimated. A young miller may further during his apprenticeship, attend the technical classes which are held at some of the milling centres, and sit for the annual examination. But supposing his education ends here, as it does at present in the majority of cases, he may have the practical knowledge of the mill's working, the practical work of the conditioning plant, and how to set the rolls, but this knowledge, some of the operatives know quite as well as he does. Thus the future head of the business is in a sense little better off, except as regards his school education, than William on the roller floor, or Smith in the screen room, so it would appear that something more is certainly needed by the miller of the future, for though Milling is an art, it may also be said to have become a Science.

The thorough miller must be a "Master Craftsman," but he must be also something of a Scientist, and have undergone a further training which should have taught him the necessity and value of the Scientific Method.

In America, and on the Continent, there exist milling schools in which instruction is

given in what we may term the "Higher Technology" of Flour Milling. A large number of young Continental millers go to these schools to learn the principles of the Scientific Method. Germany is well equipped as regards the Science and Chemistry of Milling, for she possesses a fine school at Dippoldiswalde, also having the Miller's Laboratory at the Royal School of Agriculture in Berlin, known as the Testing Institute of the Association of German Millers. In this latter Institution, is installed a Model Mill of sufficient size to be of practical value, so that students can carry through tests of wheat from the first stage to the last, while electric ovens make it possible to watch the material, from the wheat grains to the finished loaf. For a season in every year the Laboratory is thrown open to millers and bakers, who can watch the tests, and also hear lectures, by practical men on the science of Milling materials.

In this Country, a complete scientific training can be acquired at the Aynsome Milling School, an Institution specializing in Milling and Cereal Chemistry. Young millers may enter at any time, the courses being

arranged for three, six, nine and twelve months, according to individual circumstances and time available. At Aynsome, the Scientific Method is taught, and the young miller initiated into the principles of Cereal Chemistry, Enzyme Action, and Fermentation, and is also shown how to carry out tests with scientific accuracy. By taking this course of instruction the young miller of the future may hope to gain sufficient insight into scientific work to enable him to carry out all the necessary routine tests, which are likely to occur in his milling business, and what is more important still, will learn to appreciate the value of Science, and become a "Master Craftsman" in the true sense of the word.

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THE TRAINING OF THE FLOUR MILL CHEMIST

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THE TRAINING OF THE FLOUR MILL CHEMIST.

IN the last chapter I briefly sketched the training that should be followed by the young Master Miller and in this present chapter I propose to deal with the training of the Cereal Chemist who may be employed in mills from twenty sacks capacity and upwards.

In the first place the flour mill chemist should have received a good modern education during his school days, similar to that previously outlined in the last chapter. After leaving school the future chemist should enter on a three years' course of study at one of the Universities or Technical Colleges of which there are now quite a number to choose from. During the first year General Chemistry, Physics, Mathematics, Engineering, German and Freehand and Model Drawing should be studied. In the second year Organic Chemistry, more advanced Physics and Engineering. During the third year Special Methods as applied to the Chemistry of the Carbohydrates might with advantage be considered, and some

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Research work undertaken in conjunction with the Professor or one of the Lecturers in Chemistry. After leaving College I am strongly of opinion that six months in a Flour mill is desirable, after which a further three to six months of special study in the Methods of Analysis and Chemistry as required by a mill, is essential. This can best be carried out in a Laboratory or Institution specializing in Cereal and Milling Chemistry.

This Course should embrace the following:—

1. The Chemistry, Morphology and Embryology of the Cereals.
2. The use of the microscope and the examination and identification of the Starches.
3. The Analysis of Mill Offals and Feeding Stuffs.
4. The examination of Improvers and their chemical and physical action on flours.
5. The complete analysis of Flour and Flour ash.
6. The examinations of Self raising Flours, Baking powders and aerating agents.
7. Studies on the proteids of Wheat and other Cereals.

8. Studies on Bleaching and the chemical changes relating thereto.
9. Studies on Fermentation, Yeasts, Barms, nature of alcoholic and other fermentations, Malt Extracts, Baking, etc.
10. General analytical Methods as applied to the assaying of Lubricating Oils, Coals, Boiler Waters, etc.

Unless a chemist has had a thorough training on the above lines he cannot properly fulfil the duties intrusted to him, give satisfaction to his employer and take the required interest in his work which is necessary to complete success. Furthermore, it is important that the milling chemist of the future should possess a good knowledge of mechanics and electrical engineering, so that he not only fills the analysts position successfully, but is also able to look at any proposition or process which is presented to him from an engineering standpoint.

Another important qualification of the milling chemist is that he should be a good draughtsman. This fact is becoming daily more and more essential, for without this knowledge he will be unable to make his own designs or to submit drawings to his employer

a task which frequently falls to the lot of a technical adviser in the daily round of commercial practise.

I have therefore plainly shown that a milling chemist must undergo a special technical training if he is to rise to a higher and more important position in the Industrial World and if he is to be of real value to his employer he must have a varied knowledge of Science.

It is futile to expect a miller of the old school, who has probably been occupied since his youth with the engineering and business management of his mill, to keep scientific knowledge, now so essential to the business of modern milling, always ready at his finger tips. It pays him rather to employ a chemist or to consult an outside expert.

Having briefly sketched the course of study which should be pursued by those intending to qualify themselves for the position of technical adviser to a flour mill, I will now come to the work the chemist is expected to undertake. This is, without doubt, many sided, and frequently beset by more than ordinary difficulties, and because of the latter, the miller should select as his chemist, a man

who is really qualified to fulfil his duties, possessing not only a good general knowledge of his subject and a wide experience in practical work, but a man who has been trained to the task of continually attacking and following out new problems and fresh lines of work.

I have previously pointed out that it is most essential for a milling chemist to possess a fair knowledge of engineering, which will be found useful over and over again, more especially when it becomes necessary to apply laboratory results to milling practise. Two of the greatest mistakes made by manufacturers generally are (1) in refusing to see or appreciate the possibilities of a new idea when presented on its theoretical basis only and (2) in adhering to the rule of restricting the sphere of the chemist to the laboratory alone.

In order that the chemist may carry out his work successfully he should be allowed access to all the departments of the mill, and to all sources of information, as every little piece of knowledge may be of value to him and may make all the difference between the ultimate success or failure of the work upon which he is engaged.

If the chemist is to have the run of the whole mill however, his employer must have absolute confidence in him, because of the many secrets which must necessarily be intrusted to him. These secrets, it will be his duty to jealously guard on all occasions, but without a knowledge of them how can he obtain a grasp of the matters brought before him, or give his best services in the interests of the Firm by whom he is employed?

Perhaps the most important duty of the milling chemist is the analysis and control of the raw materials coming into the mill, as this will insure a standard quality of materials being maintained and avoid those difficulties which arise from variations in the same. Daily tests should be made as to the moisture of the wheat mixture as it comes from the silo on to the mill, and the results carefully kept in a book for future reference. If some system of spraying moisture on to the stocks is employed the moisture in these should be determined and a daily record kept. The temperature and humidity of the screen-room should be daily recorded. Each new wheat as it comes to the mill should be tested for total proteids and wet and dry gluten, and

when carrying out these tests a small Seck Laboratory Mill and set of sieves will be found very useful. In addition, when examining new wheats, a small testing plant of ½-sack capacity is very advantageous, such as the "Compactum," manufactured by Messrs. Samuelson and Co. of Banbury. Such a plant is invaluable for testing new mixtures and enabling the chemist to confirm the results previously obtained in the laboratory. A milling sheet should be kept in conjunction with this plant, recording the percentages of dirt, chaff and foreign seeds in every batch of wheat, the proportion of bran, offals and flour resulting from the test, the amount of moisture in the conditioned and natural wheat, and the gross and nett gains from the process. The natural moisture of the wheats going to the washer and silo should also be daily recorded, as well as the moisture in the resulting flour (ex mill) showing the gain on the flour produced. The flour should be tested at least once a week for total proteids, wet and dry gluten, acidity, soluble extract, water absorbing power by Jago's Viscometer, and the colour measured by Robert's Colourator, when any variations from the standard would be instantly recorded.

Baking tests should also be carried out regularly, certain quantities of flour, water, yeast and salt being strictly adhered to. An electric oven, such as that devised by Messrs. Christie Bros. & Co., is excellent for this purpose.

The chemist should also be able to test all coals used at the mill for steam-raising purposes, for sulphur, ash, and calorific power, and on the results obtained all contracts should be based.

He should also be familiar with the general chemical and physical tests employed in the examination of lubricants, such as specific gravity, acidity, saponifiable value, flash point and viscosity, for in many instances considerable saving can be effected by the careful examination of the oils used.

In addition to these, the assay of phosphoric acid and improver powders, which are now so extensively used, should receive the chemist's careful and systematic attention, every consignment coming into the mill being carefully checked and compared with the previous delivery.

Besides these regular daily duties and routine tests which I have mentioned, the

question of research should receive attention, and a certain amount of time should be allowed the chemist, in order to follow some problems which may later be turned to industrial value and account.

Apart from the ultimate good which may result to a milling business by so doing, research is an excellent means of stimulating those engaged in chemical work to renewed efforts, keeping alive the imagination and the brain fresh and up to concert pitch, so to speak.

The faculty of research has been defined by W. M. Gardner as a "logical and original investigation inspired by imagination and directed by special knowledge." The value of the experience gained by those engaged in original work is beyond dispute. The nature of the research must necessarily be considered in relation to the facilities which are available for carrying it out. Circumstances may, therefore, to a great extent determine the nature of the subject undertaken. When a suitable subject has been chosen the chemist must first have a definite knowledge of any work which has previously been undertaken in a similar direction. The sources of available

information under present conditions may be divided into four sections :—

(I) Text-books and Dictionaries.

(II) Journals of the Chemical and other Societies.

(III) Technical and Semi - Technical Journals.

(IV) Patent Literature.

As regards the mill chemist, with whom I am specially concerned, the following books and journals will be found indispensible as regards cereal investigations :—

Jago's Technology of Bread-making.

The Book of Bread. By Owen Simmons.

An Introduction to Bacteriological and Enzyme Chemistry. By G. J. Fowler.

The Monographs. Published by the Cambridge School of Biochemistry and Agriculture.

Papers in the Agricultural Science Journal. B yProfessor T. B. Wood.

The Vegetable Proteids. By Thomas B. Osborne.

The General Chemistry of the Proteins. By S. B. Schryver.

Various Papers contributed by A. E. Humphries, Biffen and Wood.

Training of the Flour Mill Chemist

Sundry Papers in the Journal of Industrial and Applied Chemistry, American Chemical Society, etc.

Throughout the laboratory work many problems will occur, all of which, if worked systematically to a logical conclusion, will be found of value and importance to an up-to-date miller, even if many of them are answered in the negative, and in several instances will be the means of revealing to him secrets the value of which at present he may be entirely ignorant. Many millers, no doubt, who read my remarks on Research will retort that the expense entailed in carrying out technical work of a speculative character is not desirable for a mill laboratory, but should be kept within the four walls of a Technical College or University. No greater mistake, however, could be made by those running a large milling business by adopting this course, especially if an intelligent and clever chemist is employed, for by allowing the chemist to engage in research work is the best means of kecping him bright and alert in brain, routine work alone being the surest way of stifling any originality he may have at first possessed.

What is obviously wanted in the case of

all those employing chemists is to let that chemist feel that his efforts are appreciated and that every confidence is placed in him. If the miller shows this interest in his chemist, gives him all the practical assistance in his power, and trusts him, even though the final results of an investigation are long delayed, then he may be sure in nine cases out of ten that trust will not be abused, his kindly feelings will be reciprocated to the full, and in the long run his confidence and appreciation will be rewarded by results of a permanent nature, which will increase his business a hundredfold.

OILS AND LUBRICATION

CEREAL LABORATORY (AYNSOME).

OILS AND LUBRICATION

THE lubrication of Milling Machinery is a subject of much importance to the miller, although perhaps it does not receive the attention due to it.

With the keen competition existing in flour-milling to-day, the difference between the cost for power of running a mill in which every bearing is well lubricated, and that of running a mill in which the same care is not taken, may mean the difference between a dividend to the shareholders or none.

The choice of lubricants is more often guided by the price and description, and, as long as these two factors are correct it rarely happens that a Miller considers he can gain any useful information from chemical and physical tests—apart of course from practical tests on the machinery itself, when there is always a risk of damage being done by the use of unsuitable materials.

Efficient lubrication is, however, of prime importance to the users of machinery, and this can only be obtained after one has gained

a knowledge of the chemical and physical properties of the oils and greases which are to be used.

Before discussing the practical side of this subject it may be as well to say a few words on the Theory of Lubrication, more especially relating to low and high speeds.

Lubrication may be defined as the intervention of grease, oils, balls, or rollers between load-bearing surfaces, with the object of reducing friction. Grease and oil are aggregations of microscopical balls or spheres which support the load, and keep the surfaces apart in very much the same way that the same object is effected by metallic balls or rollers.

A ball-bearing on a machine or bicycle illustrates very clearly this function of a lubricant.

The balls are pushed in between the surfaces, and convert what would otherwise be rubbing friction into rolling friction.

It will be quite apparent that the balls that are gripped between the surfaces where the load is supported are required for the time being to transmit a force sufficient to resist, and consequently equal to the load, in order

to keep the surfaces apart, and in exactly the same way the microscopical balls of a lubricant have to transmit a force corresponding to the load to keep apart the surfaces of a shaft or bearing.

When surfaces are lubricated, the oil between them is in the form of a film. At low speeds the lubricant has an opportunity of escaping from the moving surfaces, and, if the load is too great or the rubbing surfaces are of unsuitable materials, there is danger of so cutting or tearing the bearings that they will run hot. As is well known, frictional resistance is the greatest at low speeds, especially when the load is heavy, and at this period the lubrication is imperfect.

As the speed increases comparatively thick films of oil are drawn by motion of the shafts between them and their bearings separating them and therefore carrying the load.

When this takes place the lubrication is perfect.

The viscosity and oiliness of a lubricant are two of its most important properties, the latter, however, having less influence upon efficient lubrication, as the speed increases, than the former.

Both viscosity and oiliness are distinct properties although related to each other. It is generally found that with oils of the same class, the "Oiliness," which is in other words the friction reducing power of an oil—at low speeds, is in the same order as the viscosity. This, however, is not true when comparing a mineral with a vegetable oil. In this case, both may have the same viscosity and yet the vegetable oil will always be found to possess greater friction-reducing power owing to its being more "Oily," than the mineral oil. This is one of the chief reasons why blended vegetable and mineral oils are advocated by some makers—the vegetable oil in the mixture imparting a power of reducing friction to the blend—which the mineral oil by itself would not possess.

Everything, however, depends upon speed and load, for as speed increases the film between the surfaces becomes more complete, so that the reduction of friction becomes more and more dependent upon the viscosity and less upon the oiliness of the lubricant employed.

In the case of cylindrical journals, the friction at high speeds, when the oil film

has established itself, becomes nearly independent of the load, and should be proportional to the viscosity of the lubricant. Change of viscosity has a considerable effect upon the carrying power of the bearing. Thus, if the latter becomes heated the viscosity will of course be lowered, and frictional resistance reduced, and although at first sight this would appear to be advantageous, it is by no means so, as the reduction in viscosity frequently accounts in a large measure for the failure of bearings to carry heavy loads at high speeds.

In selecting an oil it is necessary to know the intensity of pressure on the bearings, so that a lubricant having corresponding "Body" may be used.

It is also requisite on account of safety to know the Flash Point, or lowest temperature at which the oil vapour will ignite.

The property of an oil to oxidise or in part evaporate, generally termed its "Tendency to gum," is important, as well as its freedom from acid, or tendency to develop free acid through increase of temperature. Pure mineral oils should be free from acidity, but animal and vegetable oils for the most part contain small quantities or traces of acid. Of the

various vegetable and animal oils used in lubrication the following may be mentioned: Southern Sperm, Arctic Sperm or bottle-nose Whale, White Whale, Neats-foot Oil, Lard Oil, Refined East Indian Rape, Refined Black Sea Rape, Cotton, Cocoa Nut, and Castor Oils.

With regard to pure mineral oils, these vary in colour, from pale yellow to red or black.

Pale yellow oils may be Russian, Galician or Austrian. A pale yellow oil with a bluish or reddish bloom by reflected light, *i.e.* when looked at sideways in a bottle or beaker glass, is most likely American in origin. Oils without much bloom and having a clear and bright red appearance are nearly certain to be American, probably Pensylvanian: whilst brownish red oils having a strong bluish or greenish bloom by reflected light are also American, very likely Texas oils.

Black oils which have a greenish cast by reflected light and when viewed in thin layers appear brown, are almost sure to be Russian. Oils which are deep brownish black by reflected light, deep brown in colour in thin layers, and not much smell, may be Roumanian or

American, whilst mineral oils having a strong, rather pungent smell, are probably Galician in origin.

Of the various oils just mentioned, fatty oils retain their body best under heat, whilst Russian mineral oils lose their thickness more under heat than American. For this reason Russian oils are not considered suitable for engine cylinders; and also on account of their low flash point.

In tropical and hot countries, castor oil is much used, though as a general rule it is found to blend badly with mineral oils unless previously treated in a special manner, when it can be made to blend fairly easily, or, in other words, become miscible. In drawing up a general specification for machinery and cylinder oils, the following remarks should be carefully noted:—

I.—There must be no free acid present.

II.—Lubricating oils containing a fatty oil should not show more than 2% free fatty acids.

III.—All oils should be free from suspended matter and grit, and also free from moisture.

IV.—Pure mineral oils should be used in cylinders of engines working with surface condensers, the water from which is returned to the boilers.

V.—Pure mineral oils are to be recommended for

pressures below 70lbs. per square inch with free lubrication, otherwise in the lubrication of parts which carry very heavy loads, *e.g.* 90lbs. per square inch, five to twenty per cent. of a fatty oil may be blended with the mineral oil to increase the "Body" or oiliness of the latter.

VI.—It is recommended that no cylinder oil should have a lower flash point than 250° Cent. = 482° Fah.

The following is a specification for a DARK CYLINDER OIL suitable for pressures over 70lbs per square inch.

Specific Gravity at - 60° Fah.—0·903.
Flash Point (Closed) - 535° Fah.
Fire Test - - - 620° Fah.
Viscosity (Redwood) at 212° Fah.—184 seconds.
Cold Test - - - 32° Fah.

DARK CYLINDER OIL for high pressures and superheated steam.

Specific Gravity at - 60° Fah.—0·911.
Flash Point (Closed) - 566° Fah.
Fire Test - - - 650° Fah.
Viscosity (Redwood) at 212° Fah.—220 seconds.
Cold Test - - - 38° Fah.

MACHINERY OIL.

Specific Gravity at - 60° Fah.—0·92.
Flash Point (Closed) - 330° Fah.
Viscosity (Redwood) at 70° Fah.—350 seconds.
" " 140° Fah.—60 seconds.

SPINDLE OIL.

Specific Gravity at - 60° Fah.—0·864.
Flash Point (Closed) - 395° Fah.
Viscosity (Redwood) at 70° Fah.—275 seconds.
" " 140° Fah.—95 seconds.

Oils and Lubrication

In connection with this chapter on oils, I have thought desirable to include the results obtained on certain cylinder and machinery oils, which have been received at the Aynsome Laboratories, from millers residing in different parts of the United Kingdom. The table on the following page gives the results of the analyses of sixteen of these samples.

Of the oils, Nos. 2, 4, 6, 8, 12, 14 and 16 are cylinder oils, whilst the rest were variously described as engine and machinery oils.

It is at once noticeable that out of all these samples only one, No. 2, is a mixture of mineral and vegetable oils, of which there is just over 3% of the latter. All the other samples are pure mineral oils. The small amount of saponifiable matter being due to the presence of resinous bodies which are to be met with naturally in some samples of this class of oil.

None of the oils showed traces of acidity except No. 1, as this is seldom met with in mineral lubricating oils which have been prepared and purified in a proper manner.

As regards the cylinder oils, all of them came out well in the volatility test, and had

TABLE

	1	C 2	3	C 4	5	C 6	7	C 8	9	10	11	C 12	13	C 14	15	C 16
Specific Gravity at 60° F.	0·8996	0·9048	0·9080	0·9056	0·9079	0·9022	0·9100	0·8968	0·9081	0·8906	0·8724	0·9008	0·9086	0·8808	0·8768	0·8947
Flash Point (closed)	372° F.	478° F	376° F	478° F	370° F	478° F	372° F	473° F	368° F	370° F	365° F	464° F	377° F	482° F	480° F	488° F
Viscosity at 70° F.	189	4978	885	6809	408	4888	876	5708	289	819	192	3878	185	5867	460	2966
Viscosity at 140° F.	68	1788	84	988	68	404	94	220	68	62	58	396	68	302	72	201
Viscosity at 200 F.	49	185	50	196	44	145	52	82	48	57	38	246	44	115	46	60
Volatility......	1·56	0·11	1·67	0·21	2·25	0·12	1·01	0·12	1·80	3·65	2·56	0·16	3· 0	0·09	0·20	0·09
Acidity as Oleic	1·62	traces	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Unsaponifiable Matter.	98·15	96·84	98·55	99·65	98·92	99·55	98·18	99·60	98·59	98·25	98·52	99·48	98·90	99·49	99·42	99·21
Saponifiable Matter	1·85	3·16	1·45	0·35	1·08	0·45	0·82	0·40	1·41	1·75	1·48	0·57	1·11	0·51	0·58	0·79

quite satisfactory flash points, although as previously stated it is well that oils for this purpose have a flash point above or as near 480° F. as possible, and certainly not lower than 460° F.

The cylinder oils showed a considerable difference in specific gravity, and viscosity, and it is therefore of importance that a miller should know how to interpret these factors correctly, so as to be able to choose an oil satisfactory for the purpose.

In passing, it may be mentioned that with all lubricating oils, when choosing from oils of the same class, assuming that the viscosities are about the same, preference should always be given to the oil having the lowest specific gravity, providing the flash point and other properties are satisfactory. This is obvious when one considers that oils in bulk are sold by weight, and consequently there will be obtained more gallons in a ton of oil of low specific gravity than there would be in a ton of oil having a higher gravity.

The cylinder oils appearing in the foregoing table are specially suitable for engine cylinders working with surface condensers, the water from which is returned to the boilers.

In such cases it would be harmful and dangerous to use a fixed oil or a blend containing a fatty oil (such as No. 2) unless the condenser water was completely purified from oil by filtration before being returned to the boiler. Oils No. 2 and No. 4 are specially suitable for engines running at comparatively low speeds and high pressures, the latter being the best suited for that purpose. Of all the cylinder oils examined No. 14 was decidedly the best, and may therefore be taken as an example of a typical cylinder oil of good quality.

As regards the other oils in the table, it will be at once seen that their properties differ considerably from each other. Samples No. 9 and No. 10 however, stand as examples of oils very similar in properties, but supplied under different names, the former being called machinery oil, and the latter an engine oil. Both came from the same mill, and as the examination of these oils showed, there was really no reason why the two oils should have been used, for either would have been quite suitable for both machinery and engine purposes, preference perhaps being given to No. 9 which was of a slightly better quality,

although higher in specific gravity than No. 10.

In a case like this, the miller would have been quite safe in purchasing the cheaper oil, but this he could not have known and appreciated unless he had had the analysis of both oils before him. Oils Nos. 1, 11 and 13 are in my opinion most suitable for fast running machinery and low pressures, and could therefore be used with advantage in lubricating purifiers and exhaust fans.

If No. 1 sample had exhibited no acidity, it would have been the best of these three oils.

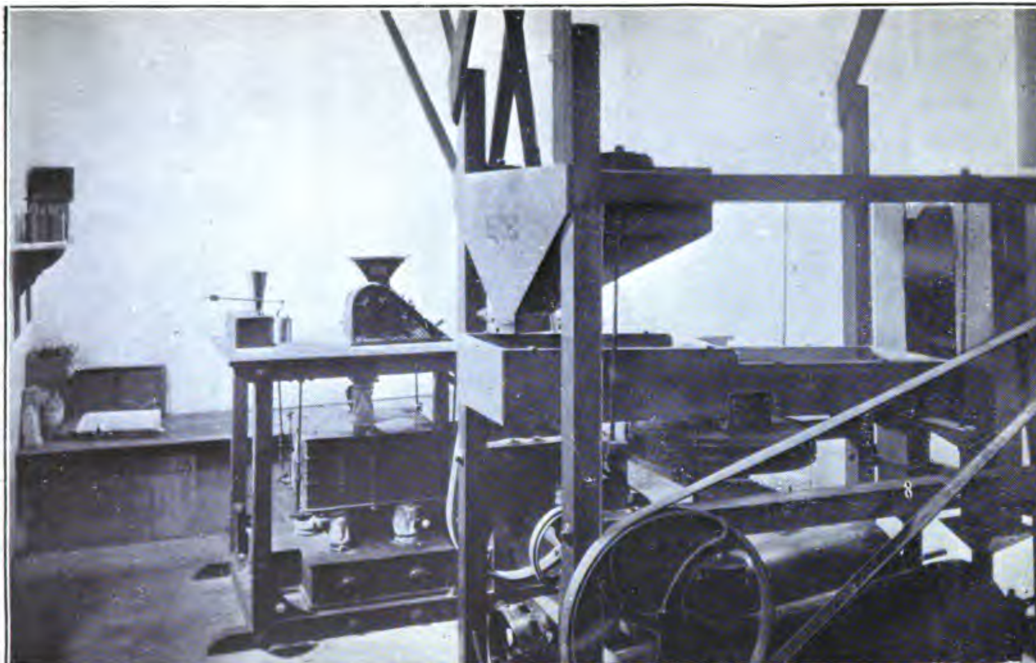
The other oils are of good quality, the ones with higher viscosities being specially suitable for slower running machinery such as centrifugals, whilst the thinner oils would be satisfactory for lubricating the faster parts such as rollers, etc.

In conclusion, it is hoped that the remarks made in this chapter will be the means of drawing millers' attention to the importance of proper lubrication, which can only be attained after having gained a more thorough knowledge of the chemical and physical properties of the oil to be employed.

Price is the third and least important

factor to be thought of. The true quality of an oil only being valued correctly after the chemical and mechanical side of the question has been fully considered and properly interpreted.

THE PURCHASE OF COALS AND OIL FUEL



BANBURY GRAIN CLEANER AND SECK LABORATORY MILL.

THE PURCHASE OF COALS AND OIL FUEL

THOSE responsible for the maintenance of power plants and the purchasing of coal for large manufacturing corporations are giving more and more attention to the possibilities of reducing their fuel bills, and have ceased to buy coal by the ton, unless safeguarded by a scientific basis of purchase.

The owners of large works and mills recognise the importance of quality as well as weight of coal. They therefore buy on a guaranteed analysis, and have regular tests and inspections made on all coals delivered for their plants. There are great variations in coal as mined and shipped to customers. The quality of coal from the same mine may vary from time to time through the failure of the colliery to reject impurities. It often happens that different beds of coal are mined at the same time and the output all mixed together.

When the coal requires further preparation, as washing or the removal of such

impurities as slate, a great deal depends on the care exercised by those carrying out the operation.

The collieries are, in a large measure, responsible for variations in the grade of the prepared coal, but by adopting the principle of buying under a contract on the basis of quality, it will be found that pit owners take greater care in preparing the coal before it is sent out.

The variation in coal from different pits may be due to moisture, volatile matter, sulphur, and ash. These differences affect the heat units, or calorific value of the coal, which naturally means a loss to the customer.

Articles, other than coal, are not bought and sold in such a haphazard manner. Wheat and corn are carefully graded, wood pulp and cotton are always tested and examined; ores are not purchased from some particular mine, but are paid for on the basis of an analysis, which clearly states the moisture, insoluble matter, metallic iron, and phosphorus. An up-to-date owner of a flour mill should buy coal in the same way and for the same reason.

The real object in buying coal is to obtain a certain amount of power or heat. To do

this with the greatest economy, that is, to get the most power or heat for a sovereign, the coal must be selected not only on the basis of its price, but after its calorific or heating value has been determined, and then both considered together.

Millers who do not give much attention to their coal supplies cannot expect that there should be any incentive to a colliery or merchant to deliver the best on the market, but when the merchant knows that a miller regularly tests and inspects his coal, he is much more likely to supply that miller with a regular and uniform quality.

By carefully considering these points, and by selecting a coal which is well adapted to the conditions of the mill boilers in use and at the same time is low in price, when the calorific value is considered, may make as much as 10% reduction in the fuel account, and may mean a considerable saving, according to situation, per thousand tons of coal, which will more than repay the expense of having regular tests undertaken.

In the perfect furnace the value of coal should depend entirely upon the heat units which are available in the coal. This being

so, the calorific value would be the true basis for the purchase of coal. Unfortunately, the size of the coal, even though it is equally high in calorific value, is a very important factor in the combustion on most types of furnaces.

As a general rule the smaller the coal, the more difficult it is to burn, on account of the difficulty of drawing air through the fuel bed. Further, in small sized coal there is almost certain to be a greater percentage of Mineral ash than in the larger sizes. With coal of small size a much stronger draught is required, which frequently carries a large amount of the very fine fuel off the grate before it has a chance of being burnt, and if it should not *cake*, a considerable quantity is lost, due to sifting through into the ashpit.

In choosing a coal for the boiler, it is probable that a careful comparison by chemical analysis is the more sure and reliable method, than a boiler test, if the former is based upon a representative sample of the bulk, as delivered at the mill. There is more certainty of doing accurate work in a laboratory than in a boiler house. For instance, the fireman may unintentionally affect results by his method of handling the fire. It generally

requires a few days for the fireman to become accustomed to a new quality of coal, and even those firemen who can claim long experience find it difficult to burn the same coal two days running in succession, and supply the same quantity of air per pound of coal each time.

The boiler test, on which I find so many millers rely upon, is only at the best a rough determination, and two tests, one on each of two coals, are seldom sufficient for comparative purposes.

On the other hand, if several tests can be made, and the average of the results of them taken, it will be found that they will compare very closely with the Chemical valuation of the same samples, provided the two coals are of the same general character.

The analysis of coal shows the miller the percentage of moisture, volatile matter, fixed carbon, ash, sulphur, and calorific value.

When coals contain a high percentage of moisture the weight is naturally increased, and a considerable amount of water is paid for at the same price as coal. A certain amount of heat is therefore wasted in vapourizing the water. Stated roughly, this loss of heat amounts to about 1 per cent. for each

10 per cent. of moisture, based on the combustible matter in the sample. When moisture is present in large amount, as it is in some coals, there is a serious loss due to the heat necessary to evaporate this water from the coal, and consequently a reduction in the temperature of the furnace gases.

The volatile matter is of importance as indicating the probable difficulty with which coal can be completely burnt with little or no smoke.

In some coals the volatile matter is almost entirely combustible, but as a rule it contains some inert matter, and as the volatile portion varies in different coal deposits, it is quite impossible to determine by a proximate analysis alone the heating value of any particular coal. Further, though there may be practically the same proportion of volatile matter in two different coals, they will not on account of this reason behave the same in the boiler furnace.

The mineral ash, like the moisture, must be looked upon as an impurity, and has no value. It is therefore an important matter to the miller, for a large percentage of ash indicates a low heat value. Ash, moreover,

carries away a large quantity of unconsumed carbon, when the furnaces are cleaned, the percentage of cinder being considerably larger in amount than the percentage of ash indicated by the analysis. This indirect waste is sometimes as much as 50 per cent. of the theoretical ash constituent. Ash clogs the fire and necessitates cleaning more frequently. This lessens the efficiency of the furnace, and more labour and attention is necessary on the part of the fireman.

The composition of coal ash may be roughly stated as follows:—

Silica	50 per cent.
Alumina and Iron ...	1·34 per cent.
Lime	6 per cent.

And Sulphuric Acid a small percentage.

The iron and sulphuric acid are derived from the sulphide of iron (pyrites) which is often found in coal, and is mainly responsible for the formation of clinker; the oxide of iron forming what is known as a flux, with the silica; the lime present adding to the fusibility of the silicious matters. On the other hand, coals containing only a small percentage of ash are more volatile, not only on account of their correspondingly higher heating capacity, but because there is less clinker present, and so

there is less resistance to the free passage of air through the bed of coal.

Moreover, the cost and labour in managing the fires and of handling the ashes are considerably less, which has an important bearing on the selection of coal for industrial purposes.

Sulphur is considered an undesirable element in coal. It very often gives trouble from clinker, and is sometimes destructive to the grate bars. The action of sulphur depends upon the form in which it occurs, and on the percentage of ash in the coal. Coals having a sulphur contents varying from a half per cent. up to six per cent. are successfully burned under boilers, and in most cases no difficulties are experienced.

In determining the calorific value the results are expressed as calories, or as the number of pounds of coal necessary to convert one pound of water into steam. In order to obtain the calorific value of a fuel three ways are available. By the first method, what is known as an ultimate analysis may be made, and the theoretical calorific value ascertained by calculation. In this method the carbon, hydrogen, nitrogen and oxygen are determined,

but as elaborate and complicated apparatus is required, and a considerable time is necessary to perform the various estimations, it is not desirable to adopt this method without the services of a trained chemist. In the second method, the moisture, volatile matter, fixed carbon and ash can be estimated, and the calorific value calculated, from one of the formulæ given by several well known authorities.

In the third method, the actual calorific value is determined by an apparatus called a Calorimeter. The principal upon which all calorimeters depend is the same, *viz.*, the burning of a weighed quantity of coal, and observing the rise in temperature imparted to a known amount of water by the heat given out during the complete combustion of the sample.

There are several types of calorimeters, the most common and simplest being the "Lewis Thompson."

A much more accurate apparatus, however, is the "Berthelot Mahler Bomb," as modified by Bryan Donkin. For the description and full details as regards the working of these calorimeters, I refer the reader to some standard test book dealing with the analysis

of coals and coke, where full working directions will be found in detail.

With regard to the sampling of coal for analysis great care should be taken, as the accuracy of the calorific value will depend on this being properly carried out. Unless the sample is what it professes to be, *i.e.*, one the composition of which is the same as that of the whole bulk of the fuel under consideration, it is useless to waste time and money in making elaborate tests.

In order to obtain an average sample the following directions should be carefully followed.

Take equal quantities from the top, middle, and bottom of the heap, place in a barrow until two cwt. has been collected. Knock down the sample on a stone floor or iron plates until the whole is reduced to the size of road metal. Mix thoroughly, make into a square and quarter it. The two opposite quarters are removed, the remaining two quarters are mixed, and the particles further reduced. The process of quartering is repeated, and always followed by thorough mixing until finally a sample of about 2 or 3 lbs. is obtained, which can then be used for analysis.

The Purchase of Coals and Oil Fuel

When placing tenders for coal the following clause might with advantage be inserted in the form of contract, especially in the case of large mills, when requiring fresh supplies of fuel.

> "The coal shall be delivered in a reasonably dry state, free from stones, dirt, and fine slack, and shall contain on delivery.........per cent. of large, which shall be that portion retained on a metal screen of...........meshes to the linear foot, and shall develop when tested in............calorimeter not less than.........thermal units per pound of the dry coal, and shall leave no more than...........per cent of mineral ash when completely burned in a muffle furnace."

Turning now to the consideration of fuels other than coal, the most important and one which has recently been receiving increased attention is oil. Oil as a fuel is now largely used to run engines in countries and districts where gas and coal are not readily available, and its use has increased enormously since the introduction of the Diesel Oil Engine. Before this engine came on the market there was practically no oil engine which could be run with heavy oils as fuel. The successful introduction however of the Diesel engine at once gave a great impetus to the oil fuel trade,

since it was found that the crudest and commonest oils could be used. The chief features claimed for the Diesel engine are as follows:—

(1.)—The temperature necessary for ignition of the fuel is attained by mechanical compression alone, so that an injected flame, incandescent tube, electric spark, or other extraneous igniting device is abolished.

(2.)—The injection of the fuel is carried out after compression has been completed, the compression in the working cylinder being therefore that of air alone. Hence no explosive mixture is in the cylinder during compression, and hence no premature ignition is possible.

(3.)—The fuel is injected gradually into highly heated air, each drop burning immediately so that no explosion takes place.

From these few particulars will at once be seen the importance of the Diesel engine for industrial purposes. Fuel used in oil engines is derived from petroleum, which is a liquid product found naturally in the earth. Petroleum is either reached by boring, or is found issuing from the ground as in the oil fields of America and Russia. The oils from Russia differ from those obtained in America chiefly in the amount of paraffin wax content. The former contain little or no wax, whilst

the latter oils contain wax in variable amounts. It is owing to this fact that Russian oils will bear exposure to lower temperatures better than American oils without solidifying. Paraffin oil is very commonly used for fuel in certain makes of oil engines. This oil is a limpid colourless liquid with of course the usual mineral oil "Bloom," and is the fraction which comes off in the distillation of petroleum after the lighter spirits such as benzine and naphtha have been abstracted. American paraffin oil ranges in specific gravity from 0·780—0·811, whilst that from Russian oil has a specific gravity of about 0·824. It is however the crude or common black petroleum oils with which this chapter is most concerned. These oils are produced principally in America and Russia, notably in California, Texas, and Baku, the bulk of the Russian business being a liquid fuel industry. As regards elementary composition the Russian oils contain slightly more carbon and less oxygen than those from America. The following table (by Usquhart) shows the properties of the oils and other fuels:

Description.	Sp. Gr.	Carbon.	Hydrogen.	Oxygen.	B.T.U.	Evap. Power.
Pensylvanian heavy oil	0·886	84·9	13·7	1·4	20·736	21·48
Caucasian light oil ...	0·884	86·3	13·6	0·1	22·027	22·79
Caucasian heavy oil ...	0·938	86·3	12·3	1·1	20·138	20·85
Petroleum refuse ...	0·938	87·1	11·7	1·2	19·832	20·53
Good English coal ...	1·380	80·0	5·0	8·0	14·112	14·61

The flash point of crude fuel oils average 240° F., and should in no case be below 170° F. The specific gravity ranges from 0·85 to 0·96 at 60° F. Oils having a specific gravity above 0·97 at 60° F. are not suitable as fuel for oil engines. The viscosity as determined by the Redwood Viscometer should be under 1,000 seconds. Moreover, the oils should be free from carbonaceous matter, sand, and dirt. As previously stated, the Russian oils contain practically no paraffin wax, and as regards American oils this should not be present in these oils to such an extent as to make them congeal or thicken at 32° F. One of the most important properties of an oil used for fuel purposes is its calorific value, since this is a measure of the total combustible matter contained by the oil. In oils for fuel purposes the calorific value should not be less than 10,000 calories, or 18,000 B.T.U. Sulphur, moisture, and earthy matter lower the heating value, and have a bad effect on the boilers and furnaces. It is therefore most important to ascertain whether these substances are present in an oil, and if so, in what proportion. No good fuel oil should contain more than 1 per cent. of moisture, or 3 per cent. of sulphur.

Any trace of acidity must of course be absent, and this should always be carefully tested for. The reader will therefore gather from the foregoing remarks that oil fuels should be subjected to a careful examination before they are used, as an oil of inferior quality is almost sure to cause trouble, and even if it is cheaper than other oils on the market it will really be dear, due to its inferiority, and will never pay in the long run to use. With the increasing demand for oil fuel which is bound to occur in the near future, oils good and bad are sure to find their way on to the market, so that it is imperative for customers to first ask for samples, and have them tested thoroughly as regards their properties and quality, before placing a contract. Whilst writing this chapter on coal and oil fuel, a description of the new battleship "Queen Elizabeth," which has just been launched at Portsmouth, has appeared in the daily press. The "Queen Elizabeth" being the first British battleship fitted to burn oil, and not coal, in her bunkers. I have therefore thought it desirable to include a portion of the revised admiralty specification for oil fuel (1912), as this may be useful for those using oil fuel as a means of motive power.

"(1) QUALITY.—The oil fuel supplied shall consist of liquid hydro-carbons, and may be either:—

"*(a)* Shale oil, or

"*(b)* Petroleum as may be required, or

"*(c)* A distillate or a residual product of petroleum,

"and shall comply with the Admiralty requirements as regards flash point, fluidity at low temperatures, percentages of sulphur, presence of water, acidity, and freedom from impurities.

"The flash point shall not be lower than 175°F. close test (Abel or Pensky-Marten).

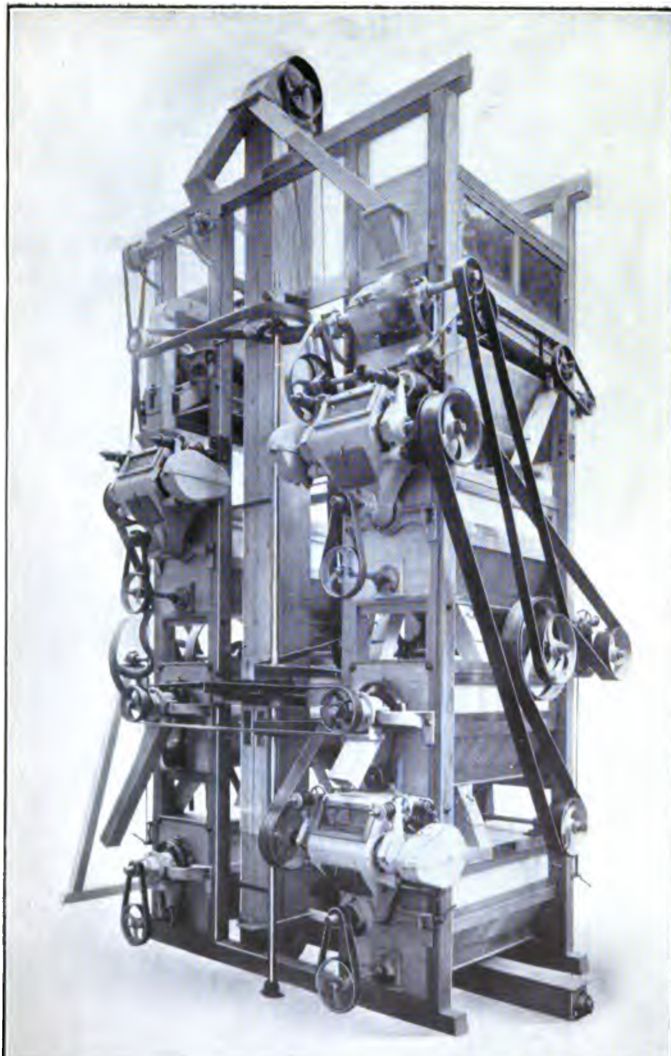
"The proportion of sulphur contained in the oil shall not exceed 3·00 per cent.

"The oil fuel supplied shall be as free as possible from acid, and in any case the quantity of acid must not exceed 0·05 per cent. calculated as oleic acid when tested by shaking up the oil with distilled water and determining by titration with decinormal alkali the amount of acid extracted by the water, methyl orange being used as indicator.

"The quantity of water delivered with the oil shall not exceed 0·5 per cent.

"The viscosity of the oil supplied shall not exceed 2,000 seconds for an outflow of 50 cubic centimetres at a temperature of 32°F. as determined by Sir Boverton Redwood's standard viscometer (Admiralty type for testing oil fuel).

"The oil supplied shall be free from earthy, carbonaceous or fibrous matter or other impurities which are likely to choke the burners."



BANBURY "COMPACTUM" MILL (HALF-SACK).

The Purchase of Coals and Oil Fuel

In concluding this chapter on coal and oil fuel, I cannot too strongly urge millers, especially those running a large business, the importance of this fuel question. From my own experience of the Milling trade in the past and the usual way I have seen the boiler house run in most mills, there is without doubt much room for improvement, especially in these days of cut prices and small profits, when every penny saved is certainly a penny gained in the final results on the year's working.

MOISTURE IN WHEAT AND FLOUR

MOISTURE IN WHEAT AND FLOUR

IN these days of modern milling practise, a factor to be remembered by those who are responsible for the buying of wheats for the mill is the question of moisture.

Apart altogether from the fact of supply and demand, which naturally always must fix the level of market values, the dryness or otherwise of a sample of grain is an important consideration in guiding a miller as to the price he ought to pay.

At one time colour was the chief guide as to the value of wheat, and though colour still has a value, the qualities which millers have learned most to appreciate are strength and moisture. Many millers have believed in the past that certain grades of wheat have a uniform percentage as regards moisture, but since the advent of moisture testers this belief has been shown to be erroneous, as it has been proved over and over again that the moisture content varies considerably in different parcels of the same grade of wheat, enough in fact to

have a marked effect on the value. Still, many millers continue to buy wheats on the basis of appearance only, and look upon the practise of testing every delivery as it comes to the mill as waste of time, and unnecessary.

If all millers who possessed a Moisture Tester would follow the practice of examining their wheats, and not leave the Moisture Tester dirty and neglected in some little hutch which goes under the proud name of the laboratory, they would certainly be in a better position as buyers. By carrying out determinations for moisture in a systematic manner, millers would obtain conclusive evidence as regards the variable percentages contained in separate deliveries of the same kind of wheat, and know better when buying, at a future time, what they might reasonably expect as regards moisture content. One of the most useful purposes to which a moisture apparatus can be put to, next to testing new deliveries of wheat, is in ascertaining the moisture of the grain after washing and conditioning.

In these days this has become more than ever an important question, now that so many systems of conditioning are in use. During the last twenty years the washing of all foreign

wheats has become the general practise. Some millers washing in cold, others in warm, and others again in hot water. These differences in washing practise, naturally have a marked effect on the moisture content, which is still further apparent in the subsequent process of conditioning.

Whatever system of washing and conditioning is employed, the miller's object is to so treat the different wheats, that the mixture, when it comes to the first break, shall have an even "Condition" or "Temper," and break down under the rolls in a free manner, without cutting the bran.

"Conditioning" to-day must be regarded as a highly technical and scientific operation, especially in the case of large mills using a variety of wheats in their "Mixture." By regularly testing the mixed wheats going to the first break roll, for moisture content, most valuable information can be gained, which to the miller who knows his business can be turned to profitable account in the future control of the conditioning process.

Another useful purpose to which the moisture apparatus can be used, is in the testing of the various stocks and offals. This

is becoming especially important at the present time in the face of the rapidly growing practise of adding water, in the form of a fine spray or vapour, to flours and offals. This addition of moisture requires considerable judgment and care, at certain seasons of the year, especially in the case of those millers who use a large proportion of mild wheats in their mixtures. In the ordinary course, where no spraying is practised, millers who use a fair proportion of mild wheats frequently find that the flour produced in the Spring is often softer than usual.

Should the weather be warm this soft condition will be very apparent, much more so than if the weather is cold. This change may be traced to the effect of nature towards germination due to the extra moisture contained in the mild wheats. In any case, it is a dangerous time for the country miller, greater care being however necessary should he be using some system for adding water. It would therefore be desirable in those mills using a spraying system, and where a considerable quantity of English wheat enters into the mixture, to restrict the amount of spraying after the middle of April, and take

every precaution to regularly ascertain the moisture content. Should spraying be continued without due care during the summer months it will not only be found that the offals have a tendency to keep badly, but there is a great risk of the flour becoming lumpy, and in any case the chance of consignments being returned, so that, though moisture may be the miller's profit, it is the height of folly to try and overstep the boundary line which nature and science have indicated as undesirable, if uniform and reliable products are to be produced. As regards the question of moisture apparatus it will be found that there are several types now in use. The usual method is to use a water-jacketed oven heated by gas. A still better tester is the "Aynsome" oven heated by electric lamps and covered with asbestos. The latter is to be prefered, being much cleaner, and requiring absolutely no attention. Another apparatus which has found much favour amongst millers is the "Reform" moisture tester, supplied by Messrs. Henry Simons, Ltd., Manchester. This type of apparatus is the outcome of the want which has been long felt in the milling trade for a reliable means of making moisture tests in

a short space of time on such materials as wheat, flour, bran, maize and malt. The amount of water contained in any of the above materials can be ascertained in about half-an-hour, whereas an oven will take several hours. The "Reform" tester consists of a brass retort, iron tripod stand, condensing chamber, graduated glass collecting tube, thermometer, brass funnel, and glass measuring tubes, and the reagents required for carrying out the tests are a light lubricating oil, turpentine, and toluol.

The mositure is distilled over into a graduated tube, the water settling on the top of the turpentine which has distilled over with it. Another apparatus also working on a distilling system is that supplied by Messrs. Thomas Robinson & Sons, of Rochdale. This apparatus is made in two compartments for duplicate tests on the same sample of grain, and also in a battery for six tests, so that three determinations can be carried out in duplicate at the same time. The method of determining the moisture in the grain by this apparatus consists in boiling the whole grain in a mineral oil having a flash point much above the boiling point of water,

condensing the water which distils off, and collecting and measuring it in a graduated test glass. This apparatus has the advantage of only requiring the mineral oil, no toluol or turpentine being necessary. A single determination can be made in about half an hour. Another type of tester is the Cylindrical Vacuum Oven, the vacuum being maintained by an apparatus known as a filter pump, worked from a water supply. A further apparatus for the determination of moisture is the Remington tester. This consists of a

Erratum

The word "water" in second line of paragraph on page 80 to read "turpentine." The word "turpentine" on third line of paragraph to read "water."

means a partial [illegible]
the mositure can be determined with great accuracy, giving results on the average half a per cent. higher than by the distillation methods previously described. In a paper on moisture determinations as applied to cereals,

in the "Journal of Industrial and Engineering Chemistry," January, 1910, an investigation was undertaken by Sherman Lovatt, to find out whether a variation of one or two degrees from the standard temperature of 100° C. would have an appreciable effect on the percentage of moisture obtained under otherwise similar conditions. The conditions under which these tests were carried out was by employing a partial vacuum with a gentle current of dry air passing through, the drying being continued until the samples ceased to lose weight, and on further heating again commenced to increase in weight. The apparatus used was a cylindrical brass vacuum oven of standard type surrounded by a water jacket. The drying, as stated by the author, was generally accomplished in five hours, the time being taken as soon as the oven had reached the desired temperature in a partial vacuum and current of dry air. When the oven was unprotected by an asbestos covering and only heated by an ordinary bunsen burner, and the water jacket being partially filled with tap water, it was found that a temperature of 97° C. was regularly maintained. With a larger burner and the oven covered with

asbestos and under standard vacuum conditions of 24 inches of mercury and two or three bubbles of air to the second passing through, temperatures of 98° C. and 99° C. were obtained. By using a mixture of water and glycerine in the water jacket of the oven an even temperature of 100° C. was obtained. The water and glycerine mixture containing 20 per cent. of glycerine by volume. Still higher temperatures of 101° C. and 102° C. were obtained in a similar oven by dispensing with the water jacket and only heating the oven by a direct flame, the temperature being regulated by a thermostat. Special precautions were taken to insure that the dried samples did not absorb moisture whilst on the pan of the balance during weighing. To prevent an appreciable amount of water being absorbed, circular flat aluminium dishes with tightly fitting covers were used, the operation of weighing being carried out as quickly as possible. A table taken from the original paper shows very clearly the divergence between duplicate samples, and the corresponding results of different temperatures.

Table A.

No. of Sample.	(1)—97° Per cent. H_2O	(1)—97° Average.	(2)—98° Per cent. H_2O	(2)—98° Average.	(3)—99° Per cent. H_2O	(3)—99° Average.	(4)—100° Per cent. H_2O	(4)—100° Average.	(5)—101° Per cent. H_2O	(5)—101° Average.
1993	8·15	8·17	8·11	8·22	8·69	8·75	9·37	9·40	9·72	9·75
	8·19		8.32		8·82		9·43		9·78	
1994	8·07	8·06	8·77	8·75	9·04	9·01	9·61	9·62	9·78	9·81
	8·05		8·73		8·98		9·62		9·84	
1995	9·12	9·06	8·85	8·07	9·44	9·42	9.83	9·83	10·45	10·50
	9·00		9·08		9·40		9·82		10·54	
2151	7·09	*	8·23	8·32	8·37	8·45	9·02	9·07	9·34	9·37
	8·69		8·41		8·53		9·12		9·41	
2152	8·29	8·29	7·90	7·76	8·66	8·62	9·31	9·36	9·47	9·41
	8·28		7·62		8·58		9·41		9·36	
2154	8·29	8·35	8·09	8·11	8·59	8·67	9·23	9·28	9·59	9·59
	8·42		8·12		8·75		9·33		9·59	
2155	8·36	8·40	8·50	8·55	8·77	8·75	9·46	9·36	9·65	9·63
	8·44		8·61		8·73		9·28		9·61	
2156	8·38	*	8·09	8·17	8·40	8·48	9·04	9·09	9·60	9·60
	7·07		8·25		8·56		9·14		95·9	
2176	8·18	*	8·23	8·30	8·51	8·45	9·16	9·16	9·51	9·52
	7·85		8·38		8·40		9·16		9·53	

* Duplicates not sufficiently close to average.

In considering the above table, the author states that all results were taken at the point where the samples commenced to increase in weight. Columns (1), (2) and (3) correspond to temperatures 97°, 98° and 99°, and were obtained with an oven with water only in the jacket. Column (4) corresponds to 101° C., and was obtained in the same oven with a 20 per cent. by volume solution of glycerine and water. Column (5) corresponds to 100° C.,

and was obtained in a hot air vacuum oven regulated by a thermostat. A further table is given so as to show the effect of heating at 100° C. for different lengths of time.

TABLE B.

ALL TEMPERATURES 100° C.

No. of Sample	(a)—3½ hours. Per cent. H_2O	Average.	(b)—4½ hours. Per cent. H_2O	Average.	(c)—5 hours. Per cent. H_2O	Average.	(d)—Over 5 hours.
1993.	9·24	9·28	9·37	9·40.	9·37	9·40	Sample increased in weight.
	9·32		9·43		9·43		
1994.	9·42	9·44	9·61	9·62	9·61	9·62	Sample increased in weight.
	9·45		9·62		9·63		
1995.	9·09	9·09	9·33	9·33	9·96	9·94	Sample increased in weight.
	9·10		9·32		9·91		
2151.	9·00	8·93	9·02	9·07	9·30	9·24	Sample increased in weight.
	8·87		9·12		9·17		
2152.	9·19	9·21	9·31	9·36	9·31	9·36	Sample increased in weight.
	9·24		9·41		9·41		
2155.	9·16	9·00	9·23	9.36	9·23	9·42	Sample increased in weight.
	8·93		9·28		9·37		
2156.	8·72	8·72	9·04	9·09	9·16	9·15	Sample increased in weight.
	8·77		9·14		9·13		
2176.	8·77	8·82	9·16	9·16	9·29	9·31	Sample increased in weight.
	8·88		9·16		9·32		

From the above figures the author concluded that a variation of 1 degree either below or above 100° C. made a marked difference in the moisture results. It will thus be seen that though it is stated in certain pamphlets relating to moisture-testing apparatus that an ordinary intelligent workman should easily

learn to make the determinations, the accurate working of such apparatus requires special care if reliable and trustworthy results are to be obtained. It is with the object of showing how fluctuations in temperature and the length of time in drying when using an ordinary vacuum oven must be carefully considered that I have discussed the original paper by Sherman Lovatt at some length. Turning now to the question of the moisture content of flour, it would appear that its importance is only recognised by a few millers and ignored by the many. It will, however, be obvious that when wheats are ground containing varying proportions of moisture the resulting flour will not be of a uniform character. Every miller desires flour of even quality, but a great many overlook the fact that variations in the moisture content is a factor that will affect the baking value of the flour. Moreover, the fluctuations in the moisture of flour are detrimental to its sale, as many of the larger bakers now carefully test their flour for moisture, and by doing so very soon find out the miller whose flour is irregular as regards moisture content. Enough has been said, however, to convince any intelligent

TESTING FLOURS BY ROBERTS' COLORATOR.

miller of the importance of careful and systematic moisture-testing, whether this being employed in connection with new deliveries of grain, subsequent conditioning, or as regards the finished article.

IMPROVERS AND ENRICHMENT PROCESSES

IMPROVERS AND ENRICHMENT PROCESSES

DURING the last few years several striking changes have been witnessed in the milling trade of this country, especially as regards the utilization of Science in the Processes of Conditioning and Bleaching, and within more recent times by the introduction of methods for the treatment of the various stocks during the milling process, as well as numerous powder preparations which are intended to be added to the finished flour, and are known as Improvers. Of the many preparations on the market, one of the commonest is acid calcium phosphate. The basis of all improvers containing acid calcium phosphate is bone, which consists largely of phosphates and carbonates of lime. This country derives its chief supplies of bones from South America, Russia, and India, whilst smaller quantities are obtained from the home

markets. The following analysis will show the composition of raw bone:—

Moisture	20·46 per cent.
*Organic Matter	34·09 " "
Phosphate of Lime	39·21 " "
Carbonate of Lime	4·16 " "
Alkaline Salts	1·14 " "
Sand	0·94 " "
	100·00

* Containing Nitrogen - 3·63 per cent.

Previous to being converted into bone ash, the bones are shovelled on to a sorting table, and all hoofs, horns, and any pieces of iron are removed. They are then passed through a mill which cracks them, after which they are sent up an elevator and are discharged on the top floor of a building known as the extracting house. The process of extraction is carried out in order to remove the fat which is now usually accomplished by benzine, though the old method was to use steam. After removal of the fat the bones are degelatinised for glue, and are then ready to be converted into bone ash. The degreased and degelatinised bones will be found to contain less nitrogen than in the raw state, the following being an analysis:—

Moisture - - - -	= 9'25	per cent.
*Organic Matter - -	= 17'66	„
Phosphate of Lime - -	= 62'39	„
Carbonate of Lime - -	= 8'55	„
Alkaline Salts - - -	= 0'38	„
Sand - - - - -	= 1'77	„
	100'00	

* Containing nitrogen 0'97 per cent.

The bones are now taken and placed in a special furnace in which several tons can be burnt at a time. In burning the bones all that is necessary is to make a small fire of wood and allow the bones to burn themselves, which they will do readily, until they are quite white, especially if they have been stacked up and somewhat bleached by exposure to the atmosphere prior to burning. The resulting product is bone ash, which will contain as much as 90% of tri-calcic phosphate. The following analyses show the variations in composition of bone ash produced under different conditions of fire and draught:—

	A	B	C	D	E	F	
Tri-calcic Phosphate	91'74	91'46	89'79	89'09	88'95	85'18	per cent.
Unconsumed Carbon ...	0'21	0'53	1'15	1'40	1'46	1'60	„

The calcined bones are then ground into a fine powder, and to every 28lbs. of the white

ground material 22lbs. of sulphuric acid, having a specific gravity of 1·57, equal to a Twaddell strength of 114°, is added together with a little water. An acid of this strength contains 85 per cent. of anhydrous sulphuric acid and 15 per cent. of water. On the addition of the acid the mixture boils up and then dries rapidly. After standing about a day the mass is put on wooden trays in a hot room to dry, and when sufficiently dried again powdered into a fine flour. The chemical reaction which takes place is expressed by the following equation :—

$$Ca_3P_2O_8 + 2H_2SO_4 = CaH_4P_2O_8 + 2CaSO_4.$$

It is, of course, important that the bone ash is treated with arsenic—free sulphuric acid—that is, acid manufactured from sulphur as distinct from pyrites. Improvers made on the above lines are sold to millers under different names, such as Cream Powders, Cream of Tartar Substitutes, whilst purer qualities, to be described later, go under various names, such as Sunrise Phosphates, Yeast Food, etc.

The following analyses give the average composition of the first-mentioned preparations :—

	A	B	C	D	E
Acid Calcium Phosphate - -	43'00	38'56	28'55	31'97	25'20
Tribasic Calcium Phosphate - -	7'26	2'79	15'78	11'63	19'05
Calcium Sulphate -	45'00	54'40	51'94	50'81	51.18
Insoluble Matter -	*Traces*	0'14	1'63	0'44	0'13
Oxide of Iron - -	0'13	0'10	0'58	0'36	0'19
Moisture etc. - -	4'61	4'01	1'52	4'79	4'25
	100'00	100'00	100'00	100'00	100'00

Purer qualities consisting of the same powders, but containing a less percentage of sulphate of lime, are made by using three-quarters sulphuric acid and one quarter phosphoric acid, or half sulphuric acid and half phosphoric acid. Powders made on these lines will give the following analyses :—

	A	B	C
Acid Calcium Phosphate -	61'56	41'74	46'16
Tribasic Calcium Phosphate -	14'24	25'59	23'46
Calcium Sulphate - - -	17'63	25'92	21'13
Insoluble Matter - - -	*Traces*	0'05	0'24
Oxide of Iron - - -	0'26	0'31	1'06
Moisture, etc. - - -	6'31	6'39	7'95
	100'00	100'00	100'00

An article of a still higher degree of purity is obtained by treating the bone ash with phosphoric acid alone. The acid used in the preparation of these last-mentioned

improvers is usually obtained by first treating the bone ash with sufficient sulphuric acid to convert the whole of the lime into calcium sulphate, and thus liberate the phosphoric acid. The residue from this reaction has the following composition :—

Calcium Sulphate - -	79·05
Oxide of Iron - - -	1·06
Organic Matter - - -	0·95
Moisture - - - -	18·94
	100·00

This has to be separated from the liquid portion, which is weak phosphoric acid, the acid being further concentrated by heat to the strength desired. The following are some of the various strengths of liquid phosphoric acid found on the market :—

Specific Gravity -	1·750 =	88·8 per cent. H_3PO_4
" " -	1·730 =	87·0 " " "
" " -	1·725 =	86·7 " " "
" " -	1·710 =	85·0 " " "
" " -	1·700 =	84·5 " " "
" " -	1·500 =	67·0 " " "
" " -	1·349 =	54·0 " " "
" " -	1·300 =	45·0 " " "
" " -	1·200 =	31·7 " " "

Improvers made with phosphoric acid usually have the following composition :—

	A	B	C	D
Acid Calcium Phosphate	67'26	58'07	58'23	42'27
Tribasic Calcium Phosphate	20'25	29'46	27'79	42'45
Calcium Sulphate	5'89	6'24	3'88	4'37
Insoluble Matter	0'14	0'09	0'14	1'84
Oxide of Iron	0'56	0'42	0'63	2'06
Moisture, etc.	5'90	5'72	9'33	7'01
	100'00	100'00	100'00	100'00

	E	F	G
Acid Calcium Phosphate	52'26	45'85	55'27
Tribasic Culcium Phosphate	36'17	44'96	34'10
Calcium Sulphate	1'43	3'03	3'15
Insoluble Matter	1'66	*Traces*	1'14
Oxide of Iron	2'48	2'01	1'52
Moisture, etc.	6'00	4'15	4'82
	100'00	100'00	100'00

Another class of improvers somewhat different to the above contain, in addition to the acid calcium phosphate, acid ammonium phosphate. The following are two analyses of such products :—

	A	B
Acid Ammonium Phosphate	39'10	40'24
Acid Calcium Phosphate	25'31	28'31
Tribasic Calcium Phosphate	30'30	25'40
Calcium Sulphate	2'10	3'03
Insoluble Matter	0'80	0'88
Oxide of Iron	0'58	0'41
Moisture, etc.	1'81	1'73
	100'00	100'00

Other powder improvers are combinations of acid calcium phosphate alone and flour, or of acid ammonium phosphate, acid magnesium phosphate and flour, or again of acid ammonium phosphate and acid calcium phosphate, the balance being flour. Improvers of the above types give analyses similar to the following:—

A

Acid Ammonium Phosphate	31·05
Acid Calcium Phosphate	2·60
Calcium Sulphate	2·28
Insoluble Matter	*Traces*
Oxide of Iron	0·13
Flour	63·94
	100·00

B

Acid Calcium Phosphate	34·49
Tri-calcic Phosphate	19·83
Calcium Sulphate	12·71
Insoluble Matter	0·32
Oxide of Iron	0·32
Flour	32·33
	100·00

The prices charged by manufacturers per ton for the various improvers I have just described range from £13 10s. to £25, according to quality. Those of the common order containing 50 per cent. of calcium sulphate

(gypsum) can be bought as low as £13, whilst those containing not more than 3 per cent. of calcium sulphate may cost about £24 per ton. Another type of improver of a much better order than any of the foregoing consists of acid ammonium phosphate or of acid ammonium phosphate, phosphoric acid and flour. An excellent improver having the latter composition, recently analysed at the Aynsome Laboratories, gave the following analysis :—

Acid Ammonium Phosphate	-	7·63	per cent.
Phosphoric Acid	- (H_3PO_4)	11·45	„ „
Flour	- - - - - -	80·92	„ „
		100·00	

A further improver very similar to the above type is one I have myself introduced, and is protected by Patent No. 14415/1911 This patent covers the use of solid phosphoric acid, which is the purest and most concentrated form of the acid. A small proportion of this acid is mixed with a malt flour of low diastatic activity and fine middlings. It will thus be seen that this preparation is both an enriching agent as well as a yeast food, and is, moreover, a product of the utmost purity.

All the foregoing improvers are supplied to millers in the form of white powders, which

it is usually recommended should be added to flours at the rate of 1lb. to 1½lbs. of improver per sack (280lbs.). They are best added by using one of the standard mixing machines as supplied by the Comet Chemical Company of Manchester, or Messrs. Gardner & Sons of Gloucester. Before leaving the question of powder improvers, it will be necessary to mention another type known under the trade name of "Salox." This consists of potassuim per-sulphate, in the proportion of 2 per cent. of the persulphate mixed with 98 per cent. of flour. It might be here mentioned that persulphates are salts of persulphuric acid ($H_2S_2O_8$). Acid potassium sulphate has the formula $KHSO_4$ whilst the persulphate is expressed by the formula $K_2S_2O_8$, and, as will be seen, contains four atoms more of oxygen as compared with the former salt.

In the presence of moisture persulphates decompose with the formation of the acid sulphate and evolution of oxygen thus :—

$$2K_2S_2O_8 + 2H_2O = 4KHSO_4 + O_2$$

It is in this way on the addition of water to a flour containing a persulphate improver that at the commencement of fermentation in the dough, it begins to decompose and liberate

free oxygen. The great advantage of this kind of improver lies in the fact that whereas 1lb. to 1½lb. of acid calcium phosphate or phosphoric acid + Flour Improver has to be used, only 1 ounce to the sack of the 2 per cent. potassium persulphate + Flour Improver is required, thus leaving the merest trace of acid sulphate in the dough and resulting bread.

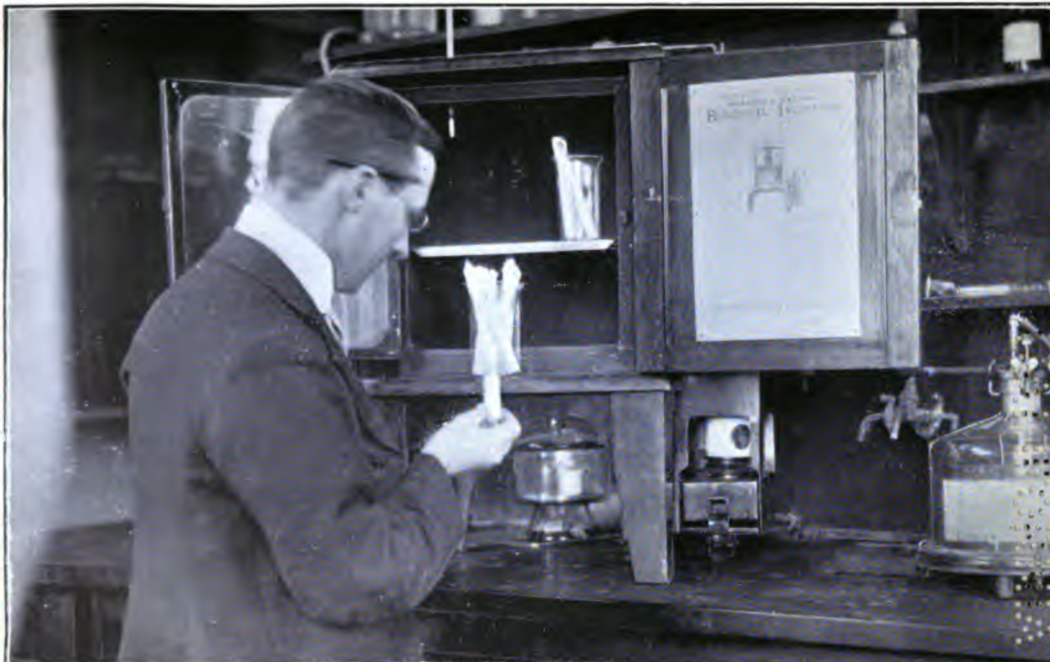
Having described the various Flour Improvers on the market, I will now turn to the consideration of other methods and processes for the strengthening and enriching of flours. Among the other systems which are now advocated for the improvement of flour is the well-known Humphries Process, which is protected by patent 13135/1908. This process in now used commercially in a large number of mills with excellent results, not only in the United Kingdom, but also in several other countries. This process is really divided in two parts.

The Conditioning Process consists in subjecting mill stocks and flour to a finely atomised spray of water, whilst in the Enrichment Process solutions containing yeast foods such as diastase, maltose and dextrine or solutions of phosphoric acid or acid

ammonium phosphates can be used. The objects which are claimed by this patent are threefold:—

1. The improvement in quality of the flours produced due to this method of conditioning Semolinas, Middlings, Dunst and Flour.
2. The improvement of the milling process on its mechanical side.
3. The addition to flour of yeast food, phosphates, phosphoric acid, and other forms of enrichment, in the most favourable and economic way.

The apparatus used and the methods employed for the Enrichment Process are substantially the same as those used in the case of the Conditioning where water only is employed. The materials used in the former process being merely dissolved in the desired proportions in the water before the latter is conveyed to the sprays. The application of the Humphries Patent was the outcome of a long series of investigations on the conditions affecting the quality of wheaten flour, the discovery having been made that the soluble matter of bran was capable of improving the baking qualities of flour, it having been shown



EXAMINING CULTURES FOR ROPE (B. MESENTERICUS).

that a water extract of bran contains mineral salts in solution, the chief being phosphates of lime, magnesia, and potash. In addition it was shown water soluble extracts contain proteins which have considerable diastatic activity and sugars. Now it is well known to every miller that the climatic conditions under which maturation and harvesting proceed in almost all countries vary widely, causing considerable changes in the grain from season to season, so that in wheats of the same character great variations frequently take place, not only as regards the character of the wheat, but also in the supply of the same wheat from year to year. At times a particular wheat is suitable without any enrichment, at other times on account of climatic changes during growth a wheat which in the previous season may have given excellent results will be found, on the flour being baked, to be deficient in its capacity to produce a well piled loaf. One cause for such deficiency may be traced to a lack of natural phosphates or other soluble salts in the wheat berry. It is here that the judicious use of phosphates will make all the difference and insure the miller being able to keep up his standard of quality. A further important point

to be remembered in this process lies in the fact that the enriching solution is applied in the form of a fine spray, this assuring an exceedingly intimate mixture of the material employed with the flour, in addition to which the usual compounds used by millers in this Enrichment Process are themselves not only natural to the wheat but also soluble and therefore enhance rather than detract the value of the resulting flour from a diatetic point of view. Finally a great advantage derived by those using the Humphries Patent is that the Enrichment Process enables millers to use larger amounts of native wheat in their mixtures and also to fall back on poorer qualities of foreign grain when a deficiency occurs in the market supply, due to bad harvesting conditions. Another method which has lately been brought before millers with the object of adding moisture alone or phosphates in solution is the Loring Process. This consists in adding water or soluble enriching agents to stocks and flour by passing them through an outer chamber of a machine similar to a Hydro-Extractor. The usual basket is replaced by a completely closed receptacle filled with water or a solution of phosphates,

and lined with felt. The centrifugal motion of the basket forces the liquid out into the chamber through which the stocks are being passed in the form of a vapour or mist which has the effect of adding moisture in a very finely divided state. A further system which has only just been put upon the market is Levin's Process. The application of moisture or enriching agents by this method is distinctly different to the two Processes previously described. Both the former processes essentially consist of adding, *i.e.* putting moisture into stocks which are kept agitated in a separate chamber. In the Levin Process the stocks, flour, or middlings are passed over a damp surface thus allowing them to absorb the necessary amount of moisture. All that is necessary is to remove a portion of the ordinary conveying spouts or shoots and replace them by a porcelain pulley or roller over which the stocks are passed. By a clever arrangement the top half of a revolving pulley is kept moistened by either water or phosphatic solutions. In addition to this method of adding moisture by means of a roll, another method is covered by the patent in which a jacketed porous shoot made of porcelain

replaces a portion of the ordinary spouting. The interior of the porous shoot can be filled with liquid which percolates through and is thus absorbed by the flour or stocks passing over it.

Whatever system however is employed whether Humphries', Loring's, or Levin's the same objects are aimed at, viz.: the restoration to the various stocks, flour, or middlings of the moisture lost in milling, and second, the enriching of the flour by the addition of weak solutions of phosphatic acid or ammonium phosphate so as to make the flour from native and mild wheats equal to that of Manitoba flour as regards soluble phosphatic content.

Having now described the various means at present employed by millers for the strengthening and enrichment of flour I will turn to the consideration of the benefit or detriment that such practise may have on the milling trade and the public. Millers are at present divided into two camps, viz.: those who favour the use of improvers and those who do not. In this connection sentiment is often a more powerful factor than practical science and when the latter crosses the border line of prejudice it very often meets

with opposition from some section of the community. People nowadays eat all kinds of food preparations into which chemicals have been introduced and as long as their prejudices are not aroused everything goes smoothly. Unfortunately there is always some "interested party" who is only too ready to work upon the feelings of the man-in-the-street and when this state of things occurs public sentiment against scientific production has to be reckoned with. Lately the composition of flour and the methods by which it is manufactured have come prominently to the fore, with the result that any change, whether beneficial or not, is looked upon with suspicion. Those who range themselves on the side of the No-Improver section never seem to question the right of the baker to make use of science nor challange the composition of the bread he produces. Yet bakers have for years used every means in their power to produce the best possible looking loaf from the flour available, many of the larger concerns making use of the recent advancements in chemistry as applied to their trade. When however the miller calls in the aid of science in order to improve the baking qualities of the flour he is at once accused of

being guilty of adulteration and fraud. Such an accusation is however most unjust and before Food Reformers accuse the miller of adulterating his flour they ought to very thoroughly study the action and effect of improvers, so as to be quite sure a real injury is being inflicted on the public, and further whether such injury is not more than compensated for by the benefit resulting therefrom. In considering the question of Improvers it is necessary in the first place to bear in mind that all wheats are not alike, but that they differ as regards gluten content both in quantity and quality. In one wheat the dry gluten may range from 6 per cent. up to 14·5 per cent. In the case of a wheat with 9 per cent. of dry gluten, the gluten on being washed out may be of good quality, on the other hand a wheat with 11 per cent. of gluten may be poor in this respect. In the first case the resulting loaf will be satisfactory, whilst the loaf from the flour of the wheat containing 11 per cent. of poor quality gluten will be unsatisfactory from the baker's point of view. One of the reasons why some wheats produce good gluten and others do not has been very carefully studied by Professor Wood, of Cambridge,

who has examined a number of flours and determined the amount of water-soluble phosphates they contain. He found that the weaker wheats contained from 0·04—0·08 per cent. of water-soluble phosphates, whilst strong Manitoba wheats (Red Fife) contained as much as 0·1 per cent. Professor Wood therefore came to the conclusion that one of the reasons for the peculiar properties of gluten was due to the variation in the water-soluble phosphate content and believed that the determination of the water-soluble phosphates gave a great deal of information as to the character of the gluten content of flour. Another paper of considerable importance was contributed by W. B. Hardy, F.R.S., entitled *An Analysis of the Factors Contributing to Strength in Wheaten Flour.* This Paper is fully described in the supplement to the *Journal of the Board of Agriculture*, June, 1910. In this paper Hardy very thoroughly discusses the peculiarities of the protein-complex, gluten, and goes on to say " Now gluten even though it be prepared from the best Fife flour has of itself neither ductility nor tenacity. In presence of ordinary distilled water it partly dissolves, the residue—the

larger portion—forming a semi-fluid sediment destitute of tenacity. Why? Because tenacity and ductility are properties impressed on gluten by something else—namely, by salts, by electrolytes, that is, which may be organic and may therefore be unrepresented in an ash analysis." The presence of salts therefore largely control the physical properties of gluten, and also effect in a marked degree the changes which it undergoes along with the other constituents of the dough in the process of baking. The addition therefore of Improvers will result in conferring additional strength on flour, especially in the case of flours produced from the milder and weaker wheats. In considering this question of Improvers it must not be forgotten that during his researches Humphries extracted the phosphates from bran and added these to flour with considerable advantage. It does not appear to me likely that anyone would contend that the phosphates from bran are injurious, therefore it only seems reasonable to infer that the application of pure phosphoric acid should not only be permissible but desirable seeing that still greater advantages result from doing so. Neither can there be any possible

harm from the addition of persulphate, for as previously stated, persulphate Improvers only contain 2 per cent. of actual persulphate in 98 per cent. of flour. It would therefore only be reasonable to permit the addition of such Improvers and pure phosphoric acid to flour. Further, such a small quantity of persulphate Improver is necessary, viz.:—1 oz. to 280 lbs. of flour, that any mineral residue left is infinitesimal in the resulting bread. No doubt chemists themselves have been responsible for a good deal of suspicion on the part of the public with regard to the use of any improver, even those consisting of persulphate or pure phosphoric acid. Those of the profession whose business it is to administer the Food and Drugs Act naturally having a tendency to try and make the standard of all foods supplied to the community as high as possible, and rightly so, and on this account from the very nature of their work and calling look with suspicion on any new process, however legitimate the aims of the inventor may be. The advantages which are claimed by the use of Improvers are important to the trade as well as to the public and may be summarised as follows :—

1. A larger percentage of English wheat can be used in the mixture.
2. Additional strength is imparted to the flour.
3. Treated flours work better and quicker in the dough.
4. An increased water absorption.
5. Larger and better piled loaves.
6. An increased number of loaves to the sack.
7. The resulting bread is lighter and therefore more easily digested.

The first advantage mentioned is especially important to small country mills that depend for their very existence on a plentiful supply of native wheat. It would, in fact, almost appear that some system of enrichment is the only future salvation of the country miller, and that the wisest policy would be to use an Improver and grind two wheats only, say English along with some Manitoba or strong Russian, of which the English formed the larger portion of the mixture.

Without Improvers the day of the small country miller appears to be numbered, depending as he does largely on English wheat which, as everyone in the Trade knows,

is deficient in strength. On the other hand the Port mills with greater facilities as regard choice of wheats, are ever growing larger and increasing their productions, so that unless some means are permissible for the country miller to utilize to the full advantage the wheats which are most easily available, so as to compete with the increased competition from outside, the day is not far distant when the majority of small mills will be a thing of the past. By using Improvers, however, the country miller can to some extent hold his own, as it enables him to take full advantage of the local wheat supply and reduce costs as regards carriage on foreign grain, which he can only obtain either by rail, river or canal. And this brings me to the important question as to what kind of Improvers or system of enrichment should be used. In considering this question it would appear to me desirable to avoid the introduction of anything which would add any inert matter to flour, even though the amount might be very small indeed, for there is no doubt that about two years ago, when the use of the acid calcium phosphate was becoming general many inaccurate statements were circulated as to their source and method of

manufacture, with the result that many people became suspicious, and were ready on the slightest pretext to brand the miller as a rogue, for selling, as they thought, flour adulterated with "donkey's bones." Though this statement was untrue, I think most chemists, and many millers, would agree that the use of acid calcium phosphate, containing even five per cent. of calcium sulphate should be discontinued, not only because the suspicions of the public would be allayed, but on account of the calcium sulphate being insoluble, and unable to impart any benefit whatever either to the flour or to the dough during the process of baking. Further, acid calcium phosphate being usually added at the rate of 1lb. to 1½lb. per sack of flour, leaves as a natural consequence, even when the purest varieties are used, a certain amount of inert-matter, which can easily be distinguished by the chloroform test on examining a flour so treated. It would, therefore, be a distinct benefit to the Trade as well as to the public if these Improvers were entirely prohibited and Improvers only permitted, which practically leave no residue in the treated flour and resulting bread, such as persulphates or Improvers consisting largely

of flour together with phosphoric acid. By the use of such Improvers all the benefit desired by the miller who uses powders would be obtained and no possible injustice could result to the purchaser from their adoption. With regard to systems of enrichment as effected by the spraying of phosphates, there could be no possible objection, as the materials used are entirely soluble. There has nevertheless been an air of uncertainty throughout the Trade with regard to all Improvers, and millers for some time have been impatiently waiting for the long promised Pure Food Bill of the Local Government Board. Recently a copy of the proposed Bill has appeared in *Milling*. This resulted in an admirable article on the Bill in the same Journal by Mr. William Jago. I am in entire agreement with Mr. Jago in his suggestion that the only way in which the inventor of new food processes, and those keenly anxious to maintain the highest standard of purity in food can be brought into line, is by the establishment of a competent Court of Reference, composed of members of the milling and baking trades, as well as of the chemical, medical, and legal professions. To quote Mr. Jago's own words:

"The inventor of any such substance as a flour improver, could submit his speciality to the Court, which on its being proved that the substance was efficacious for the purpose intended, and that it was absolutely harmless as used, and that it did not prejudice the purchaser, would give a permit for its use. There would be no objection on anyone's part to 'declare' the use of a substance which had the sanction of such a Court of Reference." It is only in my opinion by adopting some scheme based on Mr. Jago's valuable suggestion that justice can be assured to the milling trade and public alike.

BREAKFAST, INVALID, AND INFANT FOODS

ROBINSON MOISTURE TESTER AND AYNSOME ELECTRIC OVEN.

BREAKFAST, INVALID, AND INFANT FOODS

THE experience of unnumbered generations unassisted by science or any knowledge of chemistry has led to the selection of foods which are rich in compounds essential to life. Among these foods the cereal grains (wheat, oats, and barley) occupy a very prominent position.

Vegetable foods on the whole require more cooking than those of animal origin, and the cereals are no exception to this rule. This is partly due to the fact that the composition of animal foods is more nearly like that of our own bodies, and as a consequence, less change is required to fit them for absorption and assimilation.

The nutrients of the vegetable foods are for the most part locked up in minute cells, the walls of which consist chiefly of cellulose or woody fibre, a substance which almost resists the action of the digestive juices. This peculiarity of the cereal grains appears to have been discovered by man in prehistoric ages,

for there is every reason to believe that even in the most primitive time, some method of cracking or crushing the grain, before it was used for food, was adopted. The simplest and probably the first method to be employed would be to crush the grain with stones, and this would lead to the first type of mill on the mortor and pestal system. It is difficult to realise in these days of modern milling, when the preparation of the cereal grains for food has reached such a fine art, that the process had for its origin the crude operations above referred to. Nevertheless such is the case.

It is not my object, however, to deal with the milling of the cereal grains, but rather with the chemical side of the question in relation to the composition of and difference between the many preparations offered to the public in the form of Breakfast, Infant, and Invalid Foods. The analysis and examination of the numerous preparations of this kind on the market show that the cereal grains enter very largely into their composition.

The main functions of food are:—

(1) To form the materials of the body and to repair its waste.

(2) To yield heat to keep the body warm,

and to furnish it with muscular and other power for the work which it has to do.

In forming flesh, fat, bone, and the different fluids of the body, the food serves for growth and repair. In yielding heat and power it serves as fuel. Every food, whether of animal or vegetable origin, may be divided into certain groups of substances of more or less definite chemical composition, and in proportion and digestibility of these substances its value as a food depends.

Food from an animal source mainly consists of proteids, fat and mineral salts, whilst the food of vegetable origin has in addition to these substances, the carbo-hydrates. In order to show more clearly the difference between the cereal and animal foods the analysis of wheat, milk and flesh are herewith given.

	Wheat Grain	Flesh	Milk
Moisture - - -	10·62	75·00	87·11
Proteids - - -	12·25	15·00	3·61
Fat - - - -	1·73	6·40	3·69
Carbo-hydrates (starch) -	71·25	—	—
Sugar (lactose) - -	—	—	4.88
Woody Fibre - -	2·40	—	—
Mineral Ash - -	1·75	3·60	0·71
	10·000	10·000	100·00

Proteids are nitrogenous substances, the other ingredients of food are non-nitrogenous. The proteids or albuminoids are frequently described as flesh formers, and can, in themselves, supply most of the requirements of the body, a statement which cannot be made of any other food constituent. They enter into the compositions of the framework of the body, they build up and repair the muscles and tendons, and supply the albuminoids of the blood and other fluids. They are burnt in the body and may serve as fuel to produce heat and energy. Proteids, therefore, are the most valuable and most expensive food constituents to purchase.

The fats are bodies composed of carbon, hydrogen, and oxygen, and those found in the vegetable foods are similar to those found in the body. They may be transformed from one kind to another in the digestive system, or absorbed directly without change. Fat has the greatest value as a heat and force producer, its value in this respect being about 2·25 times greater than the carbo-hydrates.

The carbo-hydrates are composed of the same chemical elements as the fats, but the oxygen and hydrogen are present in the

proportion to form water—hence the name. The carbo-hydrates are the starches, pentosans, sugar, and cellulose, and these form the larger proportion of the vegetable foods. They are not stored up in the body as such, but serve as fuel for the purpose mentioned above, and are capable, when consumed in excess of the immediate requirements of the body of being converted into fat.

The ash is the mineral matter, and is composed chiefly of the phosphates of lime and potassium.

If we then bear in mind these facts concerning the food ingredients and the functions they perform in the economy of the body, it is easier to understand how it is that some foods are of more value than others. The digestibility of the ingredients is a point of the greatest importance, and one always to be taken into consideration when estimating the value of food, in fact, digestibility is the point around which the whole question of Breakfast, Infant, and Invalid Food revolves.

The various types of these foods met with on the market may roughly be divided into the following classes :—

(1) The raw or uncooked foods, or those

containing chiefly unconverted starch.

(2) The partially cooked, or those in which the cell walls of the starch have been more or less ruptured.

(3) The cooked foods, or those in which more complete gelatination of the starch has taken place.

(4) Those foods in which the starch has been converted into sugars and soluble bodies.

(5) The foods which contain soluble starch, and which in addition contain diastase or some other ferment, which quickly converts the starch in the preparation of the food.

(6) The lactated foods or those which contain desiccated milk as well as farinaceous matter.

To the first class of foods belong the farinas and flour, oatmeal, barleymeal, &c. The analyses given below are of foods taken from this class.

	Wheaten Flour	Semolina	Oatmeal	Barley Grits
Moisture - -	13'00	14'00	8'90	11'31
Proteids - -	11'80	10'99	12'50	12'70
Fat - - -	1'00	1'33	7'50	2'12
Carbo-hydrates	73'00	72'74	62'00	70'56
Woody Fibre -	0'70	0'45	7'60	1'71
Mineral Ash -	0'50	0'49	1'50	1'60
	100'00	100'00	100'00	100'00

The analysis of flour is given more for the sake of comparison, for it is not my intention to deal with various classes of flour, which, in the form of bread, supply a considerable part of the breakfast diet.

A noteworthy difference in the above foods is observable in the high percentage of fat in oatmeal, as compared with other foods. All the above foods made into porridge, and eaten with milk or cream, are both economical and nourishing providing they are subjected to sufficient cooking. It is true, however, that oat products, or even the wheat farinas are not suitable, nor do they agree with the digestive system of everyone. On referring to the analysis of oatmeal it will be observed that the woody fibre is exceptionally high, which is due largely to the imperfect removal of the husk, which acts as a mechanical irritant to the intestines, and for this reason should be removed as much as possible in the manufacture of the meal. Perfectly sound and untreated cereal grains contain practically no dextrine or maltose. The cell walls of the above foods have not been broken to any great extent in the milling process, and for this reason they require to be cooked for a longer

period, in order to make them palatable and easy of digestion. To the second class of foods belong the rolled and flaked preparations.

	Rolled Oats	Flaked Wheat	Barley Crisps	Flaked Maize
Moisture - -	10·55	10·66	10·61	9·02
Proteids - -	13·10	12·04	11·10	9·03
Fat - - -	5·06	0·89	1·43	2·26
Carbo-hydrates	68·04	74·37	74·34	78·65
Woody Fibre -	1·59	1·17	1·10	0·54
Mineral Ash -	1·66	0·87	1·42	0·50
	100·00	100·00	100·00	100·00

In the manufacture of these foods the grain is softened by steaming and then rolled and dried. By this means the grains are slightly cooked and the cell walls of the starch grains are more or less ruptured, consequently they contain more soluble starch than the foods belonging to the first class. The percentage of dextrine in the rolled oats, the analysis of which is given above, was about 3·5 per cent. showing that the starch had been slightly dextrinized. These foods, although requiring fairly prolonged cooking, are more easily prepared for the table than those belonging to the previous class. An American food of this class, known as "Wheatena," gave the following analysis :—

Moisture	6·60
Fat	2·21
Proteids	14·16
Carbo-hydrates	74·56
Woody Fibre	1·21
Mineral Ash	1·26
	100·00

In this food 3·8 per cent. of the carbo-hydrates were soluble in water. This preparation is a whole wheat product, made on the lines of Rolled Oats.

Two oat products which have a very strong hold upon the British public at the present time gave on analysis the following:—

	1	2
Moisture	7·41	11·00
Oil	6·09	5·06
Proteids	17·00	14·87
Carbo-hydrates	66·35	65·81
Woody Fibre	1·52	2·66
Mineral Ash	1·63	0·60
	100·00	100·00

To the third class belong foods similar to those of the preceding class, but for the fact that they have undergone a more prolonged cooking and are ready for the table without further preparation.

	Shredded Wheat	White Bread	Wholemeal Bread	Biscuits
Moisture - -	10·80	38·54	42·51	8·00
Proteids - -	10·25	6·80	7·50	15·40
Fat - - -	0·90	0·76	1·01	1·50
Soluble Starch and Dextrine -	4·50	(sugar) 2·37	—	—
Other Carbo-hydrates	69·32	50·27	46·94	73·40
Woody Fibre -	2·13	0·38	0·95	—
Mineral Ash -	2·10	0·88	1·09	1·70
	100·00	100·00	100·00	10·000

It will be observed that both the white and wholemeal breads are high in moisture, and, as would be expected, the wholemeal bread contains a higher percentage of ash and proteids than the white. This is due to the admixture of bran and germ, both of which are rich in proteids, phosphates of lime, and potash. An analysis of the carbo-hydrates was not made in the case of the two breads given above, except the sugar estimation in the white bread. The soluble starch and dextrine are included in the other carbo-hydrates, which are chiefly starch.

To the fourth class belong the so-called predigested foods, of which America may be called the home. During the germination of the cereal grains the large amount of starch

stored up within the seed is converted into maltose, which is a soluble sugar, and may be absorbed into the system without any further change. This conversion of the starch is brought about by a special ferment (diastase), and is similar to the action which takes place when starchy food is masticated and mixed with the saliva of the mouth. Advantage is taken of this natural process of germination in the manufacture of this class of foods. Malt is produced by causing barley to sprout, the germination being checked when the amount of the ferment is greatest. A small quantity of malt is capable of converting a comparatively large amount of starch into maltose, and if a certain quantity of malt is mixed with the cereal food under the conditions favourable to the action of the diastase a "malted" or predigested food is the result. It would appear from advertising matter on this subject that manufacturers attach much importance to this conversion of starch into soluble sugar, but to what extent the value of such a food is proportional to the solubility of the carbohydrates is a question difficult to answer. There can, however, be no doubt that people with weak and delicate digestive organs find a

food of this class very suitable, but persons in good health, possessing average digestive powers, can digest the starches in an unconverted form, and probably derive quite as much benefit from foods of the preceding classes. Predigested foods require no further preparation before use, and are usually eaten with cream or milk.

The above four classes come under the heading of Breakfast Foods, but the latter may also be termed an Invalid Food, and thus act as a connecting link between breakfast foods pure and simple, and the farinaceous foods.

Several experiments have been carried out at the Aynsome Cereal Laboratories in the compounding of foods of this class, the following being some of the results obtained:—

1. 100 grams of ground malt were mashed with 250 c.c. of water at 140° Fahr. for one hour, then strained, and the residue washed with water at 140° Fahr., the liquid being finally made up to 500 c.c. To this was added 160 grams of flour, 30 grams of germ and 10 grams of Thirds. The temperature of the mixture was raised to 140° Fahr. and kept at this figure for three hours, with continual

stirring. To half of the mixture 330 grams of flour were added, sufficent to make it into dough. It was then rolled out into thin cakes and baked at a temperature of 300° Fahr. until it became a pale brown colour and dry. The cakes were ground up very fine, and added to the other half mixture, to which had been previously added 4 grams of salt. The whole was made into a crumbly mass and baked in an electric oven at a temperature of 360° Fahr. until light brown and quite crisp.

This food gave the following analysis :—

Moisture	10·00
Oil	1·00
Proteids	10·50
Maltose	20·18
Soluble Starch and Dextrine	45·00
Other Carbo-hydrates	8·82
Crude Fibre	2·40
Mineral Ash	2·10
	100·00

The above process worked out most satisfactorily and produced a food similar in appearance and composition to "Grape Nuts."

Another food was prepared as follows :—

2. One-hundred parts of Australian wheat were heated with twice their weight of water to 175° Fahr. for half an hour, then drained and crushed. One-hundred parts of

fine oatmeal were thoroughly mixed with twice their weight of water at 167° Fahr., cooled, and the temperature raised to 140° Fahr. Ten parts of ground malt were then added in 30 parts of water and the mixture kept at a temperature of 140° Fahr. for 15 to 20 minutes. The prepared wheat was then added and the whole dried at a temperature not exceeding 140-158° Fahr.

This food gave on analysis the following composition:—

Moisture	5·40
Oil	4·12
Proteids	14·49
Maltose	35·09
Soluble Starch and Dextrine	34·30
Other Carbo-hydrates	4·27
Crude Fibre	0·63
Mineral Ash	1·70
	100·00

The following are the analyses of three well-known preparations belonging to this class, which are at present sold on the English and American markets.

	A	B	C
Moisture	12·50	8·80	6·56
Oil	1.50	0·53	0·90
Proteids	10·50	12·25	14·84
Maltose	10·10	8·50	33·62
Soluble Starch	30·00	10·79	32·14
Other Carbo-hydrates	31·04	56·90	9·19
Crude Fibre	2·06	0·83	1·70
Mineral Ash	2·30	1·40	1·05
	100·00	100·00	100·00

Breakfast, Invalid, and Infant Foods

To the fifth class belong such farinaceous foods as are suitable for young children and invalids. These are made from one or more cereal grains, which have been subjected to special treatment for the purpose. These foods may be malted and the starch wholly or partially converted. In the latter case diastase, or other ferments, are mixed with the food and the starch is converted into maltose in the preparation of the food just before use, which makes it easy to digest.

The following are the analyses of five well-known foods, 'A' and 'C' being especially popular.

	A	B	C	D	E
Moisture	4·62	6·60	7·60	8·00	10·30
Oil	0·30	1·56	3·10	0·85	1·30
Proteids	10·15	12·80	12·24	13.12	26·25
Maltose	64·06	—	46·10	12·30	3·23
Cane Sugar	4·10	—	—	—	—
Soluble Starch	—	10·50	10·00	12·25	50·00
Other Carbo-hydrates	13·07	67·04	19·76	52·58	6·05
Crude Fibre	—	0·40	—	—	0·37
Mineral Ash	3·70	1·10	1.20	0·90	2·50
	100·00	100·00	100·00	100·00	100·00

The first four foods are chiefly composed of cereal grains, 'B' and 'C' being highly malted, containing the active ferment that has

changed the starch into maltose during the analysis. The fifth 'E' differs from the others in so much as it is chiefly made from one or more leguminous seeds (beans, peas, or lentils) and barley, and contains a higher percentage of proteids. It is a food of great feeding value and very nutritious.

The majority of foods belonging to this class can be prepared by simply adding milk or water and bringing to the boil slowly, with constant stirring.

To the sixth and last class belong the lactated or those foods which are made from milk, with the addition of malt sugar or cereal flour or a combination of them all. In the manufacture of these foods and those of the previous class more than ordinary care is necessary, as they are often prescribed as the exclusive diet of those whose lives depend on the nature and suitability of this form of nourishment.

The constituents of the preparation given below are soluble or very easily rendered so. They possess little or no crude fibre, and are suitable for the most delicate digestions. On looking at the analyses it will be observed that all the foods containing desiccated milk

are rich in fat and proteids, as well as soluble carbo-hydrates. The food marked 'C' differs from the others given in the same table in containing maltose, and is sold as a malted milk preparation.

	A	B	C	D
Moisture - - -	3·50	6·70	2·54	3·00
Oil - - - -	10·00	6·33	1·50	12·20
Proteids - - -	12·25	10·50	14·30	12·25
Milk Sugar - -	48·43	11·20	50·25	50·20
Cane Sugar - -	11·80	38·00	7·27	10·55
Other Carbo-hydrates	10·32	25·47	20·87	8.40
Crude Fibre - -	—	0·20	—	—
Mineral Ash - -	3·70	1·60	3·27	3·40
	100·00	100·00	100·00	100·00

It may be said in conclusion that a great number of Breakfast, Invalid, and Infant Food Specialities have been examined at the Aynsome Cereal Laboratories, some of English manufacture and others obtained from abroad. Although the nutriment value of some of these varied to a considerable extent, yet in no case were any deleterious or injurious substances found to be present.

FEEDING CAKES AND OFFALS

FEEDING CAKES AND OFFALS

AMONG the important considerations which are of interest to the miller is the question of the composition and value of Feeding Cakes, Meals and Offals. Especially is some knowledge of these products essential to the country miller, who, in addition to his milling business, frequently deals in all kinds of feeding stuffs as used by the farmer.

Feeding cakes are divided into two classes, namely, cakes made of one substance or seed and those known as compound. Of the former, the best known to the British farmer are cotton, linseed, Soya bean and maize cakes.

Linseed Cake.

This is the refuse part or residue of the seed which is left after the extraction of linseed oil by power or hydraulic pressure. Linseed is grown in many parts of the world, and varies very much in composition. In the Journal of the Royal Agricultural Society for 1872 the late Dr. Voelcher, in a paper on the subject, gave the following table of cleaned linseeds from various parts of the world:—

	Moisture	Oil	Albu-minoids	Carbo-hydrates	Woody Fibre	Mineral Matter
Bombay	8·01	30·21	21·81	20·85	8·36	2·76
Morschauski	10·01	30·81	25·60	21·50	8·30	3·77
Black Sea	10·40	30·78	26·62	17·30	11·40	3·50
Riga	10·64	31·19	22·19	22·71	9·38	3·89
St. Petersburg	9·61	35·31	20·19	24·71	5·92	4·26
Alexandria	5·47	35·73	19·31	26·22	8·70	4·57

From the variations in composition of linseed from these different sources, as well as the methods and machinery employed in extracting the oil from the seeds, both at home and abroad, wide variations are found in the composition of the cakes as obtained from time to time on the market. Even in the same brand of cake it does not follow that the composition is always constant, as differences in the nature of the crushed seed may materially affect the feeding value. The following analyses will give a general idea of the average composition of English (A), American (B), Russian (C) and Bombay (D) linseed cakes:—

	A	B	C	D
Moisture	11·16	9·70	11·70	7·35
Oil	9·50	7·50	9·70	15·63
Albuminoids	29·50	37·30	35·25	31·37
Carbo-hydrates	35·54	33·50	30·35	25·55
Crude Fibre	9·10	7·00	7·70	9·60
Mineral Ash	5·20	5·00	5·30	10·50
	100·00	100·00	100·00	100·00

It will be seen from the above analyses that the cakes vary very much in composition. The American cakes on the average contain the least oil, whilst those made from Indian seed generally possess a fairly high percentage. With a cake containing a lower percentage of oil there is an increase in the amount of albuminoids and carbo-hydrates present, in the case of the former the increase ranging from 3–4 per cent. A linseed cake, however, containing a fair percentage of oil is much the best, as by the lowering of the oil the food units are depressed, a cake containing a less percentage of oil having a lower market value than a more oily one.

The following examples will illustrate this:—Linseed oil (A), 5 per cent. of oil (very hard American); linseed cake (B), 16 per cent. of oil (Bombay).

	A	B
Moisture	11·00	12·90
Oil	5·10	16·10
Albuminoids	31·70	28·00
Carbo-hydrates	30·20	25·00
Crude Fibre	15·00	12·00
Mineral Ash	7·00	6·00
	100·00	100·00

Linseed cake is, perhaps, the most popular

amongst farmers of all purchased foods, having a favourable action on the digestive organs. When treated with hot water the cake or meal ought to form a mildly acting mucilaginous food, having the property of counteracting the irritating properties which some foods have upon the alimentary canal, and for this reason it is often given in the form of warm gruel.

Of the impurities found in linseed cakes, these vary with the different sources from which the linseed has been obtained. The two commonest impurities are an excessive amount of sand in the ash or mineral matter, and the presence of various seeds such as mustard, rape, spurry, camelina seed, corn cockle and various forms of polygonum. The following are analyses of two high class (A and B) and two low class (C and D) linseed cakes:—

	A	B	C	D
Moisture	14·30	11·38	11·61	8·77
Oil	15·30	20·86	5·11	4·95
Albuminoids	35·50	33·19	29·56	28·30
Carbo-hydrates	22·64	24·13	37·11	40·13
Crude Fibre	7·96	6·04	9·36	10·40
Mineral Ash	4·30	4·40	7·25	7·45
	100·00	100·00	100·00	100·00

		per cent.
Albuminoids in A contained nitrogen	- -	5·67
„ B „	- -	5·87
„ C „	- -	4·27
„ D „	- -	3·97
Mineral Matter in A contained sand	- -	0·80
„ B „	- -	0·05
„ C „	- -	3·90
„ D „	- -	4·10

Cotton Cake.

This cake occurs in two forms, the decorticated and undecorticated varieties. Cottonseed is somewhat smaller than the ordinary bean, and is enclosed in a thick blackish husk, to which short fibres of cotton wool are very often attached. If the seed has been pulled some time and has become old and stale it is almost impossible to remove the husk or "decorticate" it, as it is called, so that all the decoticated cotton cakes are produced where the plants are grown and from seeds in the fresh state. When it is stated that the cakes have been manufactured in England this means that the foreign-ground cakes have been subjected to finer grinding and repressing.

Cottonseed cake and meal are very rich concentrated foods. Choice cotton cake should be bright in colour, sweet in odour, soft and

friable in texture, and should produce when properly ground a bright meal of deep canary colour.

The following are analyses of decorticated cotton cakes:—

	A	B	C	D	E	F
Moisture	8·30	13·56	11·88	13·45	11·23	9·28
Oil	12·41	5·75	5·21	5·18	12·35	16·05
Albuminoids	44·29	23·04	23·92	27·47	41·25	41·25
Carbohydrates	26·24	32·27	32·73	28·85	21·65	16·45
Crude Fibre	3·08	19·78	20·74	19·65	5·17	8·92
Mineral Ash	5·68	5·60	5·52	5·40	8·35	8·05
	100·00	100·00	100·00	100·00	100·00	100·00

Rape Cake.

This cake, when pure, is a valuable food for farm stock. That known as the German Rape Cake is perhaps the best. The flesh formers, or albuminoids, in this cake are decidedly richer than even in the best class of linseed cake. Cattle, however, do not care much for rape cake, and it is now mostly used in the form of manure rather than as a farm food. The great danger attending the use of rape cake for feeding lies in the fact that it may contain mustard or charlock seed. This has been especially the case with many of the

Indian varieties, and the results attending the use of such cakes in the feeding of stock has been most disastrous. Work in the laboratory of Jorgensen on the volatile mustard oils (carbamides) in different varieties of rape cake have abundantly proved that in every case the Indian varieties are much higher as regards the yield of mustard oil than any of the other kinds examined. The following are three analyses of various classes of rape cake. A (German), B (Indian), C (American):—

	A	B	C
Moisture - -	10·82	7·71	10·42
Oil - - -	8·72	13·29	9·80
Albuminoids - -	33·81	37·25	30·75
Carbo-hydrates -	28·06	28·48	29·92
Crude Fibre - -	11·49	5·90	11·41
Mineral Ash - -	7·10	7·37	7·70
	100·00	100·00	100·00

Cocoa-nut Cake.

This cake is made from the fleshy part or inner side of the cocoa-nut, from which the greater part of the oil has been extracted by hydraulic pressure. There are, however, some varieties of cocoa-nut cake which are made by the natives, who extract the oil by means of hand pressure. In these latter cakes as much as 30 per cent. of oil may be found. One of

the great drawbacks to the use of cocoa-nut cake lies in the fact that it very soon becomes rancid, when it is unfit for the feeding of stock. When quite fresh, stock take to this cake very well. It is, however, inferior to pure linseed cake. In some experiments conducted in Germany on the feeding of certain concentrated foods it was shown that the constituents of cocoa-nut cake gave the following percentage of digestibility with sheep :—

Crude protein (albuminoids) 95·70 per cent., crude fat 99·1 per cent., and carbo-hydrates 95·2 per cent. Large quantities of dried cocoa-nut have from time to time been imported into this country under the name of "Copra." This, when subjected to hydraulic pressure, constitutes the English-made cocoa-nut cake.

The following are analyses of English (A), American (B), and native cocoa-nut cake (C) :

	A	B	C
Moisture	9·01	9·00	11·43
Oil	9·20	13·80	23·40
Albuminoids	21·19	21·00	20·09
Carbo-hydrates	43·04	34·30	32·71
Crude Fibre	11·91	16·00	6·77
Mineral Ash	5·65	5·90	5·60
	100·00	100·00	100·00

Palm-nut Cake.

This cake is produced from the palm-nuts or kernels, which are the seed of the palm tree. These nuts contain about 50 per cent. of oil, which is a solid at ordinary temperatures and goes under the name of palm butter. Palm-nut cake is made largely on the Continent, and also to a smaller extent in this country. In some experiments conducted by Von Knieriem on the yield and composition of milk by feeding this cake, first in conjunction with clover hay and then with clover hay alone; it was found that palm-nut cake increased the yield of milk 17 per cent. The fat in the milk was also much increased. The following are analyses of palm-nut cake as offered on the English market:—

	A	B
Moisture	9·71	9·14
Oil	9·20	13·20
Albuminoids	15·91	16·62
Carbon-hydrates	40·77	36·22
Crude Fibre	19·60	21·21
Mineral Ash	4·81	3·61
	100·00	100·00

Soya-Bean Cake.

This cake is of recent introduction on the English market, and is the residue after

pressing the oil from the soya or soja bean (Glycine hispida), which is a leguminous plant extensively cultivated in Manchuria, China and Japan.

The beans are rich in albuminoids—richer in fact than any ordinary beans or peas, containing from 15 to 23 per cent. of oil and 28 to 44 per cent. of albuminoids. An average sample of the beans will contain about 17 per cent. of oil and 37 per cent. of albuminoids. The following are analyses of soya bean cake :—

	A	B	C
Moisture	11·56	12·70	12·25
Oil	5·79	11·07	9·16
Albuminoids	42·56	38·82	40·61
Carbo-hydrates	30·31	26·51	27·52
Crude Fibre	4·45	5·85	5·21
Mineral Ash	5·33	5·05	5·25
	100·00	100·00	100·00

From the above analyses it will be seen that these cakes are very rich in nitrogen and have, therefore, a high manurial value. Soya bean cake is at least as rich as decorticated cotton cake in nitrogen. When fed to stock it should be used with care and in moderate quantities mixed with other foods as an enricher.

Feeding Cakes and Offals

Maize and Maize Cakes.

Maize, or Indian corn, is the great American stock food. It is grown commercially in every State in the Union, with the exception of Arizona, Idaho and Nevada. Maize is a carbonaceous food, and its chemical composition hae been extensively studied by the New Jersey experiment station. The following table is taken from one of the Station bulletins on the subject :—

PERCENTAGE COMPOSITION OF DRY CORN KERNEL.

Original	Proportion of parts.	Ash.	Protein.	Fibre.	Nitrogen free extract.	Fat.
Kernel	100	1·7	12·6	2·0	79·4	4·3
Skin	5·5	1·3	6·6	16·4	74·1	1·6
Starchy and hard parts	84·3	0·7	12·2	0·6	85·0	1·5
Germ	10·2	11·1	21·7	2·9	34·7	29·6

Maize is of special interest to the Irish miller, large quantities of the meal being used in connection with the feeding of pigs. Irish millers are now adopting the system of treating maize germ in order to extract a portion of the oil, which can be readily disposed of to soap manufacturers. The moderate removal of the oil in no way impairs the value of the extracted product for feeding purposes. There are two main systems on the market for oil extraction, viz., by the use of

solvents or by a pressure plant. In the former system the germ is extracted by benzine, or by one of the non-inflammable solvents now on the market. Of these extraction processes the two best known are the Merz System and that of Fourcey. Though an extraction process would appear the most simple and easy of adoption it has the disadvantage of discolouring the germ, neither has the resulting oil as good an appearance as that extracted under pressure.

Maize oil freshly prepared is of a pale yellow or golden yellow colour and has a distinctive odour. The following being the average constants of a sample of the pure oil :—

Specific Gravity - - -	0·9243 at 15°c
Saponification value - -	- 191·4
Iodine value - - -	- 122
Butyro-refractometer at 15°c	- 77·4
Unsaponifiable Matter - -	1·45

The following are analyses of maize and various maize products, showing at a glance the general composition of these articles :—

	Maize.	Germ.	Meal.	Cake.	Cake.
Moisture - -	12·55	14·60	9·88	10·26	11·52
Oil - - -	4·37	24·46	5·89	4·82	8·40
Albuminoids -	10·62	14·73	11·55	11·73	12·35
Carbo-hydrates -	69·71	32·25	64·97	65·81	59·74
Crude Fibre - -	1·50	7·44	4·09	3·83	1·24
Mineral Ash - -	1·25	6·52	3·62	3·55	6·75
	100·00	100·00	100·00	100·00	100·00

Feeding Cakes and Offals

Compound Cakes and Meals.

The use of these cakes is apparently on the increase. Compound cakes are made by blending various feeding stuffs together.

Frequently ground linseed or cotton cake is taken as the basis, and the rest is made up of maize, barley, or ground cereal grains. As a general rule, the mixture is flavoured and sweetened by the admixture of some spice, such as ground fenugreek or aniseed. The pleasant aroma and sweet taste which usually accompany compound cakes and the avidity with which they are eaten by stock accounts largely for their popularity amongst farmers. The quality and composition, however, will vary very much, depending largely on the skill and judgment of the makers, and also as regards the soundness of the various materials entering into the manufacture. The following are a number of analyses of compound feeding cakes and meals examined at the Aynsome Laboratories, which very clearly represent the average composition of such articles as at present are offered on the British market :—

DAIRY MEALS.

Moisture - -	10·50	10·50	9·53	11·20
Oil (Ether Extract)	10·50	9·26	5·86	8·56
*Albuminoids -	23·57	21·01	21·84	23·58
Carbo-hydrates -	36·68	38·38	41·57	41·16
Crude Fibre -	12·30	12·70	13·95	10·30
†Mineral Ash -	6·45	8·15	7·25	5·20
Total -	100·00	100·00	100·00	100·00

Moisture - -	11·20	11·32	10·58	8·70
Oil (Ether Extract)	9·05	8·14	5·23	11·46
*Albuminoids -	21·48	22·60	26·31	21·89
Carbo-hydrates -	40·69	41·64	42·89	36·72
Crude Fibre -	9·83	9·25	8·74	13·83
†Mineral Ash -	7·75	7·05	6·25	7·40
Total -	100·00	100·00	100·00	100·00

	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.
* Containing Nitrogen -	4·77	3·36	3·49	3·77	3·48	3·63	4·37	3·50
† „ Sand - -	1·25	1·20	1·15	0·05	1·03	0·35	0·36	1·23

Moisture - - -	10·25	9·32	10·15
Oil (Ether Extract) -	8·24	8·90	7·07
*Albumnoids - -	17·43	15·68	12·18
Carbo-hydrates - -	53·75	54·80	58·83
Crude Fibre - -	6·10	7·05	5·72
†Mineral Ash - -	4·23	4·25	6·05
Total - -	100·00	100·00	100·00

	per cent.	per cent.	per cent.
* Containing Nitrogen - - -	2·79	2·51	1·95
† „ Sand - - -	0·25	0·02	0·07

Feeding Cakes and Offals

FATTENING CAKES.

Moisture - -	9·05	13·81	8·15	10·90
Oil (Ether Extract)	9·56	8·96	12·16	9·83
*Albuminoids -	24·45	19·44	25·35	20·06
Carbo-hydrates -	40·74	41·89	39·53	47·19
Crude Fibre -	10·95	8·83	9·66	5·32
†Mineral Ash -	5·25	7·07	5·15	6·70
Total - -	100·00	100·00	100·00	100·00

Moisture - -	13·00	11·60	10·25	8·30
Oil (Ether Extract)	9·23	10·32	12·80	9·80
*Albuminoids -	21·06	19·98	28·78	39·30
Carbo-hydrates -	42·25	45·31	32·80	20·93
Crude Fibre -	8·86	6·54	9·32	13·50
†Mineral Ash -	5·60	6·25	6·05	8·17
Total - -	100·00	100·00	100·00	100·00

	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.
* Containing Nitrogen -	3·91	3·11	3·41	3·21	3·85	3·19	4·61	6·28
† „ Sand - -	1·35	1·70	0·03	0·06	0·25	0·05	0·25	1·30

CALF MEALS.

Moisture - -	11·13	9·25	9·25	10·15	9·37
Oil (Ether Extract)	12·33	9·47	5·48	6·50	7·53
*Albuminoids -	22·47	31·36	20·93	18·31	19·38
Carbo-hydrates -	33·37	36·38	55·82	56·13	51·55
Crude Fibre -	13·30	7·20	5·25	5·66	7·05
†Mineral Ash -	7·40	6·34	3·27	3·25	5·12
Total -	-100·00	100·00	100·00	100·00	100·00
	per cent.	per cent.	per cent.	per cent.	per cent.
* Containing Nitrogen -	3·58	5·00	3·35	2·93	3·07
† „ Sand - -	0·34	2·05	0·05	0·15	0·37

GENERAL FEEDING CAKES.

Moisture -	9·25	12·00	10·05	11·50	10·76	9·25
Oil (Ether Extract) -	7·92	9·53	8·02	8·25	9·05	7·48
*Albuminoids	28·64	23·68	19·18	29·12	21·75	21·87
Carbo-hydrates -	36·53	34·67	53·93	39·85	45·35	45·84
Crude Fibre	10·16	13·30	5·65	6·23	8·07	9·16
†Mineral Ash	7·50	6·82	3·17	5·05	5·02	6·40
Total -	100·00	100·00	100·00	100·00	100·00	100·00
	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.
* Containing Nitrogen -	4·58	3·77	3·07	4·66	3·48	3·49
† „ Sand - -	1·02	0·12	0·25	0·02	0·08	0·25

Moisture - -	10·05	10·05	9·02	10·17	10·23
Oil (Ether Extract)	8·05	7·02	10·30	6·20	9·56
*Albuminoids -	19·18	12·18	20·50	8·69	25·02
Carbo-hydrates -	50·67	56·28	48·41	62·97	45·29
Crude Fibre -	7·00	9·20	6·02	6·73	5·80
†Mineral Ash -	5·05	5·27	5·75	5·24	4·10
Total -	100·00	100·00	100·00	100·00	100·00
	per cent.	per cent.	per cent.	per cent.	per cent.
* Containing Nitrogen -	3·07	1·95	3·28	1·39	4·16
† „ Sand - -	0·20	0·28	0·26	0·75	0·02

Bran consists largely of woody fibre or cellulose, together with a considerable proportion of soluble albuminous matter. Bran and pollards contain more albuminoids than whole wheat meal. They belong, nevertheless, to a class of foods poor in proteids, the average composition of wheat-bran being as follows :—

Moisture	13·20
Proteids	14·10
Fat	3·64
Carbo-hydrates	56·06
Crude Fibre	7·21
Mineral Ash	5·79
	100·00

According to Warrington, the amount of wheat-bran digested for one hundred parts of each constituent present ascertained by carrying out various experiments on cattle, sheep and goats was :—Total organic matter, 71; nitrogenous substances, 71; fat, 72; soluble carbo-hydrates, 76; and crude fibre, 30. The digestible nutritive matter in 1,000lbs. of wheat-bran when supplied to sheep and oxen was found to be :—Total organic matter, 612; nitrogenous substances, consisting of albuminoids, amides, etc., 77; fat, 102; soluble carbo-hydrates, 411; crude fibre, 22.

Numerous experiments have been carried out on the feeding value and influence of bran and other mill offals at Rothamstead, and also by Professor O. Kellner, of the Mockeen Agricultural Station, near Leipzig, and by many of the Experimental Stations in the United States.

Of the American experiments, Mumford, of the Michigan Station, fed corn in opposition to bran during a period of 119 days to two lots of ten lambs, having an average of 83lbs. in weight each. The result of this experiment showed a gain of 443lbs. for the corn and 242lbs. for the bran, and an average daily gain of 0·37lbs. in the case of the corn and 0·2lbs. for the bran. In further American experiments with sheep it has been shown that bran is not especially desirable for the fattening of sheep, as a large quantity is required for a given gain, bran conducing to growth rather than the production of fat.

For the feeding of cattle it is an especially useful addition to the ration because of its bulky character, and, further, on account of its slightly laxative and cooling properties, it forms a most excellent material in diluting cottonseed meal and other heavy food substances. Bran is held in high esteem by dairy farmers, though the effect of a feeding stuff like wheat-bran naturally depends upon the quality used, an excessive amount having a tendency to produce soft butter. When used, however, judiciously it is an excellent article to include in the daily ration for dairy stock.

At Rothamstead in the winter feeding of the cows the general daily diet consisted of hay, oat-straw and mangles, together with 2½lbs. of decorticated cotton cake and 2½lbs. of bran. This ration was given to every cow yielding one gallon of milk, and an additional pound both of cottoncake and bran was given for every additional gallon of milk produced. Bran may therefore be fed with good results to stock and to a limited extent to fattening pigs, the amount in the latter case being restricted, lest the volume of the food be too much increased.

Middlings and Sharps.

At the Winconsin Experimental Station W. A. Henry fed three lots of three pigs each on corn meal and wheat middlings, giving the first of the pigs corn meal, the second lot the middlings, and the last an equal mixture of the two. This experiment was carried out for forty-two days; 559lbs. of the corn meal was consumed by the first lot of pigs, 501lbs. of middlings by the second, and 476lbs. by the last set.

The gain over the period was 104, 96 and 107lbs. respectively, the feed for 100lbs. gain being 537, 522 and 439 in each case.

Further experiments, carried out at Missouri Station by Sanburn with corn meal and middlings over a period of 116 days, shows a gain of 250lbs. for the corn meal and 252lbs. for the middlings.

American experiments go to prove that as a feed for pigs at all periods of their development middlings stand pre-eminent on account of their containing much proteid matter and mineral ash. Further, on account of the much smaller amount of crude fibre when compared with bran, this feeding stuff is particularly suited to the requirements of very young pigs, ranking next to the by-products of the dairy in this respect.

During the fattening period middlings work admirably with maize for pigs, but care must always be taken when giving milling by-products not to feed them alone, but in conjunction with maize, barley, or other grains, otherwise soft pork may be produced. The following are a number of analyses of sharps made by Mr. C. C. Duncan, of Worcester, which appeared in a paper on the composition of barley meal, maize meal, and sharps in the *Agricultural Students' Gazette* of the Royal Agricultural College for December, 1911:—

	Water	Albuminoids	Oil	Ash	Fibre	Carbo-hydrates	Food Units	Ash insoluble in HC	Microscopical Examination
Sharps	13·73	16·62	4·2	3·96	5·72	55·77	110	0·2	Sharps only found.
	12·81	16·45	3·64	4·04	5·80	57·26	107	0·3	Sharps only found.
	11·92	15·92	3·59	3·58	5·77	59·22	108	0·2	Sharps only found.
	12·97	15·57	3·62	3·60	6·16	58·08	106	0·2	Sharps only found.
	10·34	13·30	3·44	5·12	6·51	61·29	103	0·9	Trace of foreign Starch.
	13·04	15·75	3·74	3·20	6·02	58·25	107	0·3	Sharps only found.
	14·18	16·18	4·06	3·78	5·71	56·09	107	0·2	Sharps only found.
	15·02	16·62	4·01	4·64	5·71	54·00	106	0·6	Sharps only found.
	13·17	15·79	3·90	4·16	5·94	57·08	106	0·2	Sharps only found.
	10·13	16·27	4·18	3·80	5·85	59·77	111	0·1	Trace of Buck-Wheat also detected.
	11·56	16·62	4·22	4·14	6·12	57·34	109	0·6	Sharps only found.
	13·24	16·97	3·82	2·92	5·20	57·85	110	0·1	Sharps only found.
	13·12	15·92	3·98	1·92	4·74	60·32	110	0·2	Sharps only found.
	13·53	15·05	4·17	5·28	8·85	53·12	101	0·5	Sharps only found.
	13·67	15·05	3·48	2·16	5.46	60·18	107	0·3	Sharps only found.
	15·12	16·32	3·70	4·30	6·11	54·15	105	0·8	Sharps found, Mites also found.
	12·97	14·70	3·42	2·36	4·72	61·83	107	0·1	Sharps only found.
	13·46	15·40	4·00	4·36	6·12	56·66	105	0·6	Sharps only found,
	12·70	15·13	4·62	4·58	8·02	54·95	104	0·8	Trace of foreign matter found.
	12·28	16·97	4·32	4·26	5·70	56·47	110	0·2	Sharps only found.
Average	12·90	15·80	3·90	3·80	6·00	57·40	107	0·4	

It will be seen from the foregoing that mill offals have quite a good feeding value, and up to the present have not been estimated at their true value by farmers. Millers, too, often look upon their offals as the residue of wheat after the milling process is completed. If, however, they would pay more attention to the question of these products and keep their eyes open the better it would be for the trade. What is wanted is for the British miller to take a little more trouble over the matter of bran and sharps and endeavour to educate the farmer as to the excellent feeding value of the same. By so doing better prices would undoubtedly be realised. When, however, a miller sells his offals for, say, £5 10/- per ton he is certainly all the time suffering considerable loss, and this he should fully realise, remembering that the price at which mill offals are sold will to a great extent control the price of flour. Americans and Germans have studied very thoroughly the food values of all available feeding stuffs, and profited considerably by so doing; but the British miller, who seems in many cases to take a pride in disregarding the ways and teachings of science, has done comparatively nothing,

still continuing to sell thirty per cent. of his products at a little over £5 per ton, when his wheat may be costing him £9 per ton. And so the price of offals will continue until the British millers bestir themselves a little more, and, though still paying attention to their flour, go out of their way to educate their customers as to the high feeding value of the by-products they manufacture.

Turning now to the functions of the constituents of foods, it will have been seen, on studying the various analyses previously given, that feeding stuffs are primarily made up of water and dry matter, and that the latter consists of nitrogenous and non-nitrogenous constituents, which again may be sub-divided, the nitrogenous into albuminoids and amides and the non-nitrogenous into fats, carbohydrates, mineral ash, etc.

Albuminoids.

The albuminoids or proteids are the true flesh formers, and are mainly utilised in the formation of muscle. They are sometimes called essential food ingredients, because without them life could not be maintained. Proteids also serve, when fed in excessive amount, as fat-forming substances and as a

source of heat and energy. They contain nitrogen to the extent of 16 per cent., which, along with part of the carbon, hydrogen and oxygen, is utilised for the formation and repair of the animal tissues.

Amides.

These constituents of foods, although they contain nitrogen, are of comparatively small value as flesh-formers. They, however, produce heat, and therefore serve the same function in the body as the carbo-hydrates. Amides are not important as regards feeding cakes, as they do not occur in any large amount in the seeds from which the chief feeding cakes are produced nor in cereal grains, so that as regards this chapter they may be left out of consideration.

Oils and Fats.

Fats and Oils are important heat producers. They, further, give mechanical force, and are to some extent a source of fat.

Carbo-hydrates.

The most important Carbo-hydrates are starch and sugar, which comprise the bulk of the feeding material of cereal grains, roots, etc. They supply heat and mechanical force,

one part of fat or oil being equal to 2·3 of carbo-hydrates for this purpose.

Crude Fibre.

This consists chiefly of cellulose, and although under certain conditions it may be so acted on in the animal's body as to have a certain feeding value, its importance in this respect is not great.

Mineral Ash.

The ash is of importance when arranging a diet for a young growing animal. This constituent of food consists chiefly of salts, which go to form bone and blood. Maize is low in bone-forming material, so that when it is used in large amount it should be balanced by other foods containing a high proportion of mineral matter.

When considering food one often hears used the expression "intrinsic value." Intrinsic value means the combined manurial and feeding value, and from this it is possible to make a rough comparison of the respective value of two or more feeding stuffs. To find the intrinsic value add the percentage of oil to the percentage of albuminoids and multiply by 2½. To the figure obtained add the percentage of carbo-hydrates, and the result

is the number of "food units" in the feeding stuff. By applying this rule in the case of decorticated cotton cake and linseed cake it will be found that the cotton cake contains more "food units" than the linseed. The former cake, therefore, is much the cheaper food, as on the average it contains 148 units as against 125 in linseed cake. Economy in feeding is only possible when the ingredients of the food are in proper proportions. The proportion which the albuminoids bear to the oil and carbo-hydrates is called the "albuminoid or nutritive ratio. Experiments have shown that for farm animals the nutritive ratio should not contain more than one part of albuminoids to four parts of oil and carbo-hydrates, or less than one part of albuminoids to nine or ten parts of the others. For example, the nutritive ratio for a fattening bullock is theoretically from one to four to one to six. In order to find the albuminoid ratio of a food, multiply the oils by 2·3 (which reduces them to the level of the carbo-hydrates), add the carbo-hydrates, and divide the figure by the albuminoids. The result will show the number of parts of oil and carbo-hydrates to one part of albuminoids.

In concluding this chapter on feeding stuffs, I cannot too strongly advocate the importance of systematic feeding experiments as regards millers' offals. Already some interest has been aroused in this direction, but much more could be done. Agricultural Colleges and County Council Agricultural Schools should be encouraged to carry out feeding experiments, for it is only by so doing that the real value of the by-products produced by millers can be brought home to the British farmer. I therefore hope that the foregoing remarks and examples of analyses will be of service to millers generally, and if I have succeeded in arousing some interest on this important question I shall feel that my labours will not have been in vain.

In the opening chapter of this book the motto that I took was, "Trust in Heaven, but tie up your camel." I hope all those who have had the patience to read through the various chapters will have seen the important bearing that Science is destined to play in the business of Modern Milling. Every year we see small mills closing down, mills which in many cases could still be working and carrying on a good and thriving trade if the owners had

only realised the importance of Science before it was too late, for in these days of increasing competition the only hope of success in the future lies in "tying up the camel"—in other words, taking note of every new development as regards the manufacturing department of the milling business, and by educating the younger generation of millers to the importance of the teachings of Science as applied to this great industry.

[THE END.]